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ABSTRACT

This report of the 1994 meeting of directors of programs funded by the Precollege Science Education Initiative for Science Museums contains proceedings of the meeting along with profiles of grant-supported activities. The community partnerships described share a common theme: the importance of science education not just as a means to an end, but also as a provider of skills that can be applied throughout our lives. The keynote address "Science for All: New Communities and New Attitudes" was delivered by Shirley Malcom. Plenary presentations included: "Big City Problems and Opportunities" (Weiss, Martin); "It Takes a Whole Village to Raise a Child" (Siska, Janice and Hemphill, Lynell); and "Flexibility and Teamwork Keep Nature Park Moving Forward" (Schatz, Dennis and Hoesterey, Roger). Panel discussions include: "Working with Schools in a Changing Environment"; "It Takes Two (or More Than Two) to Tango"; "Planning and Evaluation"; "Two Approaches to Science Education in the Urban Setting"; "Matching Program Content with Local Needs"; "Top Down and Bottom Up, Two Approaches to Working with Schools"; "Nobody Said It Would Be Easy, but it Certainly Has Been Fun"; "Evaluation and Assessment: Achieving Science Literacy Benchmarks"; and "Steepening the Learning Curve--What Are We Learning." (JRH)

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Science Museums: Enlisting Communities in Science Education Partnerships

Science Museum Program
Directors Meeting
September 26–28, 1994

Precollege Science Education Initiative for Science Museums
Office of Grants and Special Programs

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Howard Hughes Medical Institute

Science Museums: Enlisting Communities in Science Education Partnerships

Collaborations Between Communities and Science Museums, Aquaria, Botanical Gardens, and Zoos

Precollege Science Education Initiative for Science Museums
Office of Grants and Special Programs

About This Report

In the fall of each year, the Howard Hughes Medical Institute convenes a meeting of directors of the programs supported by grants from the Precollege and Public Science Education Program. The purposes of the meeting are to provide a forum for the program directors to discuss challenges in providing science education programs to children, youth, and families, and to learn from each other.

Each meeting is organized around a central theme, with plenary and panel sessions devoted to topics within that theme. The focus of the 1994 meeting was *Science Museums: Enlisting Communities in Science Education Partnerships*. The program directors discussed the challenges involved in starting a community-based science education program, enlisting partners, and evaluating outcomes. The first annual meeting in 1993 focused on *Science Museums: Creating Partnerships in Science Education*.

This report contains the proceedings of the 1994 meeting, plus profiles of the programs funded in 1993 through the Precollege Science Education Initiative for Science Museums.

The contributions of Margaret Anderson, Sarah Brookhart, W. T. Carrigan, Kathi E. Hanna, Ginger Pinholster, Margaret Sickels, and Robert M. West to the preparation of this report are gratefully acknowledged. Photographs in Part I are by William K. Geiger.

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Howard Hughes Medical Institute Programs

The Howard Hughes Medical Institute was founded in 1953 by aviator-industrialist Howard R. Hughes. Its charter, in part, reads: *The primary purpose and objective of the Howard Hughes Medical Institute shall be the promotion of human knowledge within the field of the basic sciences (principally the field of medical research and medical education) and the effective application thereof for the benefit of mankind.*

Biomedical Research Program

The Howard Hughes Medical Institute is a nonprofit medical research organization dedicated to basic biomedical research and education. Its principal objectives are the advancement of fundamental knowledge in biomedical science and the application of new scientific knowledge to the alleviation of disease and the promotion of health. Through its program of direct conduct of medical research in conjunction with hospitals, it employs approximately 280 independent investigators at its laboratories in 64 leading academic medical centers, universities, and hospitals throughout the United States.

The Institute conducts research in five broad areas: cell biology and regulation, genetics, immunology, neuroscience, and structural biology.

To aid these research efforts, the Institute is involved in the training of graduate and postgraduate students in its investigators' laboratories, has given substantial support to the international genome mapping program, provides research training to medical students through the Research Scholars Program (conducted jointly with the National Institutes of Health), and organizes scientific conferences, workshops, and program reviews.

Grants and Special Programs

To complement its research program, the Institute has a grants program dedicated to strengthening education in the biological and related sciences. This program is administered by the Office of Grants and Special Programs and is designed to enhance science education at the graduate, undergraduate, and precollege levels; to increase public understanding and appreciation of science; and to support fundamental biomedical research abroad. In addition, a comprehensive assessment effort is under way. The Institute grants reach a wide range of institutions involved in formal and informal science education, including colleges and universities, medical schools, elementary and secondary schools, research centers, and museums.

Since launching the grants program in 1987, the Institute has developed an array of initiatives to help ensure the quality and vitality of the nation's scientific enterprise. Today the Institute supports graduate students, medical students, and physicians through biological science fellowships; undergraduate institutions through a broad program of science education; and science museums and biomedical research institutions through a precollege and public science education program.

Precollege science education initiatives provide grants to science museums and biomedical research institutions.

Precollege Science Education Initiatives. The initiative for science museums was the Institute's first major effort in the precollege and public science education program. The grants enable museums, zoos, aquaria, and botanical gardens to work with students and their families, teachers, and community groups in developing educational activities that focus on biology or integrate biology with other disciplines. The program builds on the success that museums and related institutions have had in employing less traditional educational approaches to stimulate interest in science and make science meaningful to people of all ages and educational levels.

The overall objectives of the science museum initiative are to enhance precollege education in biology and related fields; to augment science teaching in the schools; to stimulate collaborations among scientists, educators, and community resource centers to the benefit of students, teachers, and the community; to reinforce the role of parents and the community in the science education of children and youth; and to increase interest in science education and research careers among women and minority groups underrepresented in the sciences.

Altogether the Institute has awarded $10.6 million in grants to science museums and related precollege and public institutions. In the 1992 competition, grants supported 29 children's and youth museums, general science museums and science-technology centers, and natural history and natural science museums. In 1993, 22 science museums, aquaria, botanical gardens, and zoos were funded. These 51 grants are supporting science education programs for children, youth, and families, for curriculum enhancement, and for teacher training. The programs give special attention to disadvantaged and minority populations in both rural and urban areas.

The initiative for biomedical research institutions is the Institute's latest effort to improve general scientific literacy through hands-on science education at the precollege level. It enables science-oriented institutions to work with schools, youth organizations, and community groups. The aim is to develop and conduct educational activities in modern biology, or in other disciplines integrated with biology, drawing on the unique resources that biomedical research institutions can offer to stimulate interest in science, particularly among young people.

The 1994 grants competition was open to biomedical research institutions that had been invited to apply. These comprised about 250 medical schools, academic health centers, and independent laboratories, selected after consultation with the Association of American Medical Colleges, Association of Academic Health Centers, Association of Independent Research Institutions, and several databases. Grants totaling $10.3 million have been awarded to 42 institutions.

Preface

Purnell Choppin, M.D. ■ President ■ Howard Hughes Medical Institute

The grants program of the Howard Hughes Medical Institute constitutes the largest philanthropic science education effort in U.S. history. Since its establishment in 1987, the program has expanded beyond science education to provide international research opportunities for scientists abroad and much-needed research resources for biomedical research institutions in the United States. These grant activities in science education and research complement the Institute's own research programs, which employ approximately 280 independent investigators. Their research into cell biology and regulation, genetics, immunology, neuroscience, and structural biology is carried out in 64 academic medical centers, universities, and hospitals.

Since 1988 the Institute has provided $323 million in grants. The grants program budget exceeds $56 million in 1995 and extends across a wide range of institutions involved in formal and informal science education. The Institute supports graduate students, medical students, and physicians through fellowship programs; colleges and universities through an undergraduate science education program; and science museums and biomedical research institutions through a precollege education initiative. With programs ranging from prekindergarten through postdoctoral training, the Institute is committed to preparing not only for the future of science but also for a more science-literate citizenry.

Grant programs supporting science education continue to grow in strength and vibrancy. Through the undergraduate biological sciences education program, the Institute has awarded $86 million in four-year grants to 62 research and doctorate-granting universities. Altogether, $290 million has gone to strengthen life sciences education at 213 public and private colleges and universities. This is the largest private initiative of its kind in the country. A primary objective is to attract and prepare students, particularly women and minorities, for careers in science and science teaching. This program is helping to spark a historic change in how young people learn science and is helping large numbers of students to carry out research in modern laboratories. Their experience so far suggests strongly that more students will get interested in science, and perform it well, if given the chance to undertake research and pursue their own curiosity.

Through its precollege program, the Institute has awarded nearly $11 million to 51 museums, aquaria, botanical gardens, and zoos to interest and educate youngsters in science. In 1994 we were pleased to expand our efforts in education by awarding over $10 million to 42 biomedical research institutions for precollege outreach.

At far too many schools, students still experience science as a tedious exercise of memorizing the elements in the periodic table, the parts of a cell, and other facts. They are

Institute President Purnell Choppin and keynote speaker Shirley Malcom.

screened out by introductory courses instead of being stimulated by them. The emphasis has been on learning the achievements of others, not on playing the game themselves. As a result, many students, especially women and minorities, never appreciate the excitement of science or consider it as a career.

We can improve this situation greatly—but only if we move beyond our usual hand-wringing about how little students know *about* science and start finding ways for them to *do* science.

Exposure to science should begin early and focus on the processes of science as well as its substance. In the past (and too frequently in the present) science education has relied on a process of memorization, rather than inquiry, resulting in a view of science as boring and irrelevant. Scientists know this to be false. When asked to explain their work, they reveal that much joy is to be had in the process of discovery. Scientists, community groups, colleges, universities, and museums are joining in partnerships with schools and teachers to help inspire the next generation.

At the 1994 precollege program directors' meeting, the Audubon Institute's Dr. Richard Guttenberg highlighted the need for partnerships at the simplest level when he noted, "We need a three-point partnership of kids, teachers, *and* their families to really promote learning. Schools are not always set up to promote parent-child interaction, but museums, aquaria, and zoos can offer a wide range of participatory programs for families."

Working scientists, museum educators, and classroom teachers, who often work apart from one another, need to collaborate on science education reform efforts. Researchers at universities, medical schools, museums, and elsewhere can help science to come alive for students and teachers by opening their doors and shar-

ing their expertise. The programs described in this book fulfill our vision of community-based learning where all comers are welcome and all may gain a broader world view through science.

It is not wishful thinking or empty rhetoric to say we need to get more young people interested in molecular biology and other sciences. It is a goal that is readily attainable with a change in strategy. The Institute has made a commitment—nationally, and at the local level—to change strategies that don't work and maintain those that do.

The challenge to improve science literacy is daunting. A nationwide survey on science literacy by the American Museum of Natural History demonstrated that a majority of Americans, while expressing concern about science-based issues facing our society, lack the basic knowledge needed to understand many of these issues. The good news is that three out of four Americans report that they enjoy learning about science for its own sake, and nearly as many agree that science will solve many of the world's problems.

Science museums have the ability to narrow the distance between the expert and the novice. They provide access to a world of learning unlike that found in schools. Museums, aquaria, botanical gardens, and zoos have a special place in our communities and possess the ability to engender trust where so many other institutions have failed. As such, they are key in creating and nurturing partnerships for science education reform.

These are hard times for the support of science and education, which must rely heavily on the beneficence and stewardship of public and private funding organizations. Efforts to reduce the national debt and reallocate scarce resources threaten long-term goals that are sometimes high risk. The Institute is committed to a future where science advances and a scientifically literate society is prepared to make informed choices about its application.

From the world's research establishments to the nation's most impoverished neighborhoods, major investments have been made. They take many forms, as illustrated in this report. Institute programs have provided a lifeline for some institutions; others have been enabled to chart new waters; and others have found an opportunity to change course. No two programs are quite the same. It is our hope that, collectively, these programs will expand knowledge, overcome disease, and teach future generations.

Introduction: Learning Through Science Education Partnerships

Joseph G. Perpich, M.D., J.D. ■ Vice President for Grants and Special Programs

The Precollege Science Education Initiative for Science Museums was the Institute's first major effort in the precollege and public science education program. The grants enable museums, zoos, aquaria, and botanical gardens to work with students and their families, teachers, and community groups in developing educational activities that focus on biology or integrate biology with other disciplines. In 1992 the Institute awarded $6.4 million to 29 children's and youth museums, natural history museums, and science and technology centers. In 1993 the initiative awarded $4.2 million in grants to 22 museums, aquaria, botanical gardens, and zoos.

The initiative for biomedical research institutions is the Institute's latest effort to improve general scientific literacy through hands-on science education at the precollege level. It enables science-oriented institutions to work with schools, youth organizations, and community groups. The 1994 grants competition was open to medical schools, academic health centers, and independent research institutions. In June 1994, grants totaling $10.3 million were awarded to 42 institutions.

The science museum program directors meeting is one of five annual grants program conferences held by the Institute. The other conferences bring together medical student fellows, predoctoral and physician postdoctoral fellows, directors of Institute-supported undergraduate programs, and Washington, D.C., metropolitan area high school students supported through the Institute's local grant activities.

The 1994 meeting was the second gathering of directors of programs funded by the Precollege Science Education Initiative for Science Museums. As with the first meeting of program directors, participants were able to share their experiences with each other and form new contacts for the future. The proceedings of that meeting are summarized in this report along with profiles of the grant-supported activities of the 1993 awardees. The focus of this year's meeting was community partnerships, a key ingredient in science education reform. The extent to which a museum, aquarium, botanical garden, or zoo had effectively reached out to its community in finding creative approaches to science education was a critical criterion by which proposals were evaluated for both the 1992 and 1993 competitions.

At the 1994 program directors meeting, the Institute asked its grantees to describe and explore the status of those partnerships, some of which were mature and established at the time of the award, while others were conceptualized only during proposal development. The partnerships described in this book are as eclectic and disparate as one might expect from organizations serving different populations across the country. They share one theme, however: the importance of science education not just as a means to an end, but also as a provider of skills

Institute Vice President Joseph Perpich and Susan Erikkson, Virginia Tech Museum of Natural History, at the opening reception for the second annual meeting of pre-college program directors.

that can be applied over and over again throughout our lives.

Why Science Is Important

Biologist Lewis Thomas wrote in his book *Late Night Thoughts on Listening to Mahler's Ninth Symphony*, "It is the very strangeness of nature that makes science engrossing. That ought to be at the center of science teaching." Thomas goes on to say that we should be teaching children not only what we know but what we don't know. We should let them know there are many mysteries yet to be solved and provide them with the tools they need to look for answers and ask more questions.

Anyone who has "done" science can describe the thrill and sense of fulfillment that can be had from the systematic pursuit of knowledge. While science can be considered a body of knowledge or a vocation, it is also a way of seeing and understanding the world that becomes a part of who we are. Barbara McClintock, on receiving her 1983 Nobel Prize for lifelong research into the genetic characteristics of corn, said, "It might seem unfair to reward a person for having so much pleasure over the years."

Thanks to numerous calls for their involvement in science education and rising concern about stewardship in science, practicing scientists are now communicating their devotion to their profession. The Institute's latest foray into science education supports the notion that scientists, as well as frontline teachers, must make an investment of time and experience in energizing interest in science.

If children can experience the thrill of scientific investigation even once, they will grow up with an appreciation of how the world can be better understood. Not everyone needs to know science as a scientist

does—and not everyone can—but the large majority should understand much more than they do now.

Through the types of programs described in this book, science activities can become standard community fare for many citizens. Joe Mims, a city parks and recreation superintendent working with the Discovery Museum–Learning Center in Sacramento, says, "It's really no different than being involved in Little League. Many kids enter, but only a few become athletes. It's the same with the museum's science project—maybe only a few will go on in science, but at least they've had the experience."

Other than a need for academic excellence in the education of our children, there are strong reasons that science education must become more effective and more exciting. Robert Hazen, coauthor of *Science Matters: Achieving Scientific Literacy* and a former keynote speaker at the Institute's precollege program directors meeting, offers three arguments for the importance of scientific literacy: one from civics, one from aesthetics, and one from intellectual connectedness.

The argument from civics is obvious. Every citizen will be faced with public issues whose discussion requires some scientific background.

The argument from aesthetics, argue Hazen and coauthor James Trefil, is more complex.

> We live in a world that operates according to a few general laws of nature. Everything you do from the moment you get up to the moment you go to bed happens because of the working of one of these laws. This exceedingly beautiful and elegant view of the world is the crowning achievement of centuries of work by scientists. There is intellectual and aesthetic satisfaction to be gained from seeing the unity between a pot of water on a stove and the slow march of the continents, between the colors of the rainbow and the behavior of the fundamental constituents of water. The scientifically illiterate person has been cut off from an enriching part of life, just as surely as a person who cannot read.[1]

In this year's keynote address, Shirley Malcom, of the American Association for the Advancement of Science, made a similar point, describing science literacy as a feeling that goes beyond just understanding formulas, charts, and graphs. "It's a sense that I can know this; I can come to understand this. It's a kind of savvy or street-wise condition that one can draw on in any arena or domain: a kind of empowerment that keeps us steady when traveling through difficult content." This type of knowledge is required of future scientists and is crucial for all citizens.

The argument for scientific literacy from the need for intellectual coherence emphasizes the central role of science in setting the intellectual climate of an era. Think of the influence on intellectual life of Copernicus in the Middle Ages and Darwin in the past century. Hazen and Trefil ask, "How can anyone hope to appreciate the deep underly-

[1]Robert M. Hazen and James Trefil, *Science Matters: Achieving Scientific Literacy* (New York: Anchor Books, 1991) pp.xv-xvi.

There is intellectual and aesthetic satisfaction to be gained from seeing the unity between a pot of water on a stove and the slow march of the continents, between the colors of the rainbow and the behavior of the fundamental constituents of water. The scientifically illiterate person has been cut off from an enriching part of life, just as surely as a person who cannot read.

Robert Hazen and James Trefil

"It's really no different than being involved in Little League. Many kids enter, but only a few become athletes."

Joe Mims

ing threads of intellectual life in his or her own time without understanding the science that goes with it?"

Encouraging Curiosity and Cultivating Discovery

In theory, approaching science education as the learning of a process that leads to discovery should be easy. Children are natural scientists: they question, they like to explore, they love a mystery. Spend time with four- or five-year-olds and you can be exhausted by their inherent curiosity. Yet children know the limits of their knowledge. Mark Twain once wrote that the "most interesting information comes from children, for they tell all they know and then stop." The adult spending time with that four- or five-year-old quickly learns that his or her knowledge, like the child's, is limited. While we, as adults, cannot be expected to have all the answers, we should not pretend that science does either.

Young learners are particularly sensitive to the environment for learning and the attitudes of those who teach them. And learning is cumulative. What children learn and how they learn will affect their progress through the rest of their educational career. Failure to educate and excite students in the early years of science teaching is a primary reason for the inadequacy of later science learning.

Museums and related institutions are particularly well poised to reach children in their earliest years. Aquaria, botanical gardens, museums, and zoos can not only help children learn science; they can bridge the gap between popular culture and school learning and provide a foundation on which children can come to develop a positive and enduring relationship with science. "School learning" is too narrow a notion to capture the kinds of experiences provided by institutions such as museums and zoos. In the words of Mark St. John and Deborah Perry, museums should see themselves as "institutional resources that, like schools and libraries, are part of the nation's educational infrastructure."[2]

Science museums are often able to inspire children when schools cannot. Howard Gardner, codirector of Project Zero at Harvard University and author of many books on multiple intelligences, attributes the power of science museums to their ability to appeal to various learning styles of children and the creation of a self-paced learning environment. The Institute is pleased that so many of the programs funded through the Precollege Science Education Initiative for Museums reach out to the youngest elementary school children and their teachers. For awards made in 1992 and 1993, over 70 percent of the students participating in Institute-funded programs were in prekindergarten to 5th grade. Forty-four percent were in pre-kindergarten to 3rd grade.

[2]"Rethink Role, Science Museums Urged," *ASTC Newsletter* 21(4), September/October 1993.

The Challenge of Science Education Reform

Concern about the critical need for improved science and mathematics education in our schools has increased over time. We have realized, as a nation, that we cannot afford to continue treating science as an optional activity in our children's lives. Recently we have witnessed constructive action as scientists and educators learn to work together to identify failures and find solutions.

Leaders in science and mathematics education have been pushing for drastic changes in the way science and mathematics are structured, sequenced, and presented. At the national level, the American Association for the Advancement of Science, the National Research Council, the National Science Teachers Association, and the National Science Foundation have a vision of excellence in the form of standards to be applied to science curricula, assessment, and teaching. These national standards provide powerful support for change at the local level.

Reform of science education is not easy because change must occur in adult institutions, not in children. Reforming the way science teachers are trained, curriculum developed, science taught, and programs evaluated requires change at many levels. "Systemic reform" and "systemic change" are terms being used to describe the integrated, comprehensive changes being proposed to transform the way science is taught in our schools.

Across these efforts there is general consensus that exposure to science should begin early and should focus on the processes of science as well as its substance. In the past (and too frequently in the present), science education has relied on a process of memorization rather than inquiry. This has resulted in a view of science that lacks excitement and curiosity. The terms "science as a way of knowing" and "science as a process" convey the message that science should be learned by doing.

The concept of hands-on learning through laboratory experiences and inquiry-based activities is now widely accepted. Such learning serves several crucial functions in intellectual development. It teaches the individual to observe, hypothesize, theorize, and develop methods by which to generate knowledge.

Hands-on research experiences promote the concept of biology as an experimental science, not just something to be learned through lectures and reading. Finally, the collection, analysis, and interpretation of data are best taught by trial and error, with opportunities provided for analysis of results and modification of experimental design. Many of the programs funded by the Institute through the Precollege Science Education Initiative for Museums provide children (and teachers) with the opportunity to develop their intellects in exciting and unique ways.

Access to stimulating learning environments has been declining nationally for many years. Some reasons are the reductions in school resources, the drive to include more

Reform of science education is not easy because change must occur in adult institutions, not in children.

The kind of science education offered by science museums lies at the heart of many of the reform efforts and should be seen as an irreplaceable supplement to school-based reforms.

curricular content, lack of laboratory experience in teacher preparation, and competing academic demands on students' time. As schools struggle with fiscal constraints, larger classes, and other problems, museums should be seen as an integral part of the educational infrastructure. They have the ability to provide a stable and magnetic resource for a diverse community of learners.

Key to reform efforts is that science be taught in the same spirit that science is done—with a sense of mystery. In his 1931 book *Living Philosophies*, Albert Einstein wrote, "The most beautiful experience we can have is the mysterious . . . the fundamental emotion which stands at the cradle of true art and true science." The immense popularity of "detective-based" programs, such as Mystery at the Museum in Chicago's Museum of Science and Industry or The Health Adventure's Medical Science Sleuth program in North Carolina, testify to the value of this approach to learning science.

Through a long tradition of hands-on learning, science museums and related institutions have influenced the science reform effort. They offer what is called constructivism, which in the simpler words of Valerie Chase, an aquarian biologist at the National Aquarium in Baltimore, is that "if you can figure something out for yourself, then you can construct your knowledge."

The traditional "cell and bell" system of education (which confines students in classrooms for 50 minutes and then hustles them off to another class) is being replaced with a more flexible learning environment that allows for connections between ideas and practical results. These new environments, which are being created inside and outside school walls, make knowledge come alive and are tremendous motivators for learning science.

Partnerships Translate the Language of Reform Into Action

The kind of science education offered by science museums lies at the heart of many of the reform efforts and should be seen as an irreplaceable supplement to school-based reforms. Examples of 1993 Institute-funded programs that work side-by-side with their local school systems to implement reform are those of the Academy of Natural Sciences, the California Museum of Science and Industry, the Children's Discovery Museum of San Jose, the Children's Museum, the National Aquarium in Baltimore, and the New York Hall of Science. These institutions provide site-based implementation of the national standards.

The partnerships being formed between schools, museums, research institutions, and their communities provide access to learning that might not otherwise be achieved. At their best, these partnerships are a key to translating the language of reform into actuality. Their versatility and flexibility bring scientific resources into the hands of teachers and their students. In addition, partnerships can be instrumental in providing

"teachable moments," those instances where curiosity is sparked, doors are opened, and futures changed. Teachable moments are what keep teachers coming to work day after day when the obstacles seem insurmountable.

Teachers are critical to reform efforts. Many of the programs featured in this book, such as those of the Exploratorium, the Missouri Botanical Garden, and the National Aquarium in Baltimore, target their efforts at teachers, providing them with new skills and materials for professional development as well as much-needed support for keeping pace with reform requirements.

Many prominent scientists have revealed that a rewarding career can start with a small push—an interesting lecture by a scientist visiting a school, a book or article, a museum trip, an inspirational teacher, or a summer science camp. Some children are naturally motivated to learn science; others need that special one-time exposure to trigger their enthusiasm. In many ways, notes Samuel Ward, keynote speaker at the Institute's 1993 undergraduate program directors meeting, it is the 99 percent of the students who are not destined to become scientists that we must try harder to reach. It is a high-risk strategy because the payoff is so uncertain, but one worth taking.

The Institute's precollege science education programs are two-pronged. They aim to improve general scientific literacy as well as to ensure the future supply of scientists. They do this by funding activities ranging from the small push that can lead to other significant science experiences to total immersion in year-long research activities.

Among the Institute-funded programs there are those involving, among other things, whales, islands, rivers, barges, and botanical gardens—integral parts of their communities. The partners include schools, churches, tribal communities, public housing developments, scientists, and families. The learners range in age from prekindergarten to senior citizens. And the experiences range from brief encounters with new content or curriculum to intense year-long experiences for students and teachers.

A Risk Worth Taking

Through this and last year's meeting of program directors, the Institute has witnessed the rich and diverse resources offered through programs such as those described in this book. What is most exciting about these programs are the partnerships being formed between the museums and their communities. The versatility and durability of these partnerships will be, perhaps, the best measure of their success. In listening to the reports of the institutions awarded HHMI grants, we are seeing that an important feature of these partnerships is that they are beginning to weave together the different strands of the science reform movement. In their own communities, museums are recognizing the many and unique dimensions of need and are responding with highly creative programs.

"Many things are taken away from children today, but education is something that will always be theirs."

Roslyn Rubesin-Eigler

Yet forming such partnerships is often an arduous task. For example, multiple layers of bureaucracy have posed unexpected challenges to Martin Weiss of the New York Hall of Science in his attempts to implement the MICROLAB Institute, which provides microbiology training for 7th-grade teachers. When it was discovered that some classrooms lacked electrical outlets, newly purchased microscopes had to be replaced with battery-lighted instruments. Junior teachers with no office or permament classroom found themselves moving pushcarts of equipment through crowded hallways. Teaching tomorrow's skills in yesterday's schools can be frustrating.

Dennis Schatz of the Pacific Science Center and Roger Hoesterey, from Parks and Community Services for the City of Bellevue, described some of the more nettlesome issues that arise in collaborating with another organization. Which logo will be used and who will receive credit for the program were typical.

Staying focused and cultivating trust seems to be the way these obstacles are overcome. Peter Dow, of the Buffalo Museum of Science, suggested that eight questions be continually asked when museums, aquaria, botanical gardens, and zoos enlist the community in science education:

- What are we trying to do?
- How do we approach the school system or community group?
- What makes a good partnership?
- How do we define collaboration?
- What does the museum have that the school or community wants?
- What does the school or community have that the museum wants?
- How do we get the principal to say yes?
- How do we relate to the movement for systemic reform?

Science is far too important to be the concern of scientists alone. It permeates much of how we live, how and what we learn, and how we order our society. A future supply of highly trained scientists and a scientifically literate public are essential, not only for solving problems that plague our health and environment but also for exploring new frontiers yet only imagined.

Roslyn Rubesin-Eigler, of the Children's Discovery Museum of San Jose, noted in her annual report to the Institute that "Many things are taken away from children today, but education is something that will always be theirs." The Institute's precollege science education programs focus on steps we can take to improve that education.

Science fiction author Ray Bradbury once said, "Touch a scientist and you touch a child." We believe the opposite is equally true: touch a child and you touch a scientist. Just as no scientist could be expected to perform without adequate resources and sufficient support, no child can be expected to succeed in science without a supportive environment that nurtures and encourages enthusiasm for learning. It is the Institute's hope that the programs supported through its precollege programs provide an open door to a lifetime of science learning.

Conclusion

New approaches to science education require far-reaching changes in the way science teachers are trained, curriculum is developed, science is taught, and programs are evaluated. Reform is not easy because it requires change at many levels in established and mature institutions. In addition, systemic change requires time and resources.

Providing an environment for learning sometimes calls for Herculean action as families and educators cope with crime, violence, deteriorating buildings, indifferent bureaucracies, and scarce resources. At the 1994 meeting of precollege science education program directors, Janice Siska of the Chicago Academy of Sciences and Lynell Hemphill of the Chicago Housing Authority described what some might consider the insurmountable obstacles of taking young children from the housing projects into the mentorship of teens and medical students at Northwestern University.

Just getting the students into the learning environment required community effort, observed Hemphill, quoting the African adage "It takes a whole village to raise a child." Once a learning environment is provided, children's natural curiosity takes over. When curiosity is sparked, constant support and encouragement can transform a child's world. Failure to arouse interest in the early years is a primary reason for scientific illiteracy in later life. But teachers can no longer be expected to provide science education opportunities on their own. The partnerships that schools, museums, colleges and universities, and research institutions are forming with their communities will provide new access to learning.

During the 1994 meeting, Siska and Hemphill presented a videotape featuring seven-year-old Christopher, who lives in the Henry Horner Homes, a well-known public housing community. Conditions there have been documented in a book (and an Oprah Winfrey movie), *There Are No Children Here*. Christopher told the camera that he had dropped out of a gang because of his dreams. "I'd like to live where there are no drugs, no gangs, no trash," he says, "where there are homes for stray animals and where there are homes for kids that are clean and warm and full of love." Programs like the one offered by the Chicago Academy of Sciences are a small but essential step toward helping some children realize their dreams.

Programs like the one offered by the Chicago Academy of Sciences are a small but essential step toward helping some children realize their dreams.

Christopher's story illustrates why, in addition to the need for scientific literacy in terms of the economy and future progress, children need to master science: individual personal empowerment. In addressing the precollege program directors this year, Shirley Malcom pondered what it must be like to live in a world where you think there is no relationship between cause and effect, that things are not knowable, not predictable. Yet many children (and adults) live their lives in just that way.

Malcom postulated two models of life: a bowler's model and a craps model. "Here is the bowler's model

of life: There is something I can do to affect the outcome. I have some power over my own existence, over my own fate. The craps model of life is: Who knows, it's all luck, it's all chance."

The question of empowerment is a real question with regard to so many of the children we want to reach. Can we give them the gift that lets them say, "I have some control over at least this part of my life"? The institutions receiving HHMI funds can give this gift through outreach and connection to their communities. Through its grants programs, the Institute is pleased to provide some of the resources needed to translate the language of science education reform into reality, to improve the learning environment of the next century, and to provide children with the ability to control their own fate.

Overview of Museum Initiative, 1992–1994

Since 1991 the Institute has developed several initiatives in precollege science education. Their objectives are to encourage students to choose scientific careers, to offer research opportunities and new teaching tools to teachers, and to address national concerns about the paucity of general scientific knowledge and interest among both school-age and adult populations.

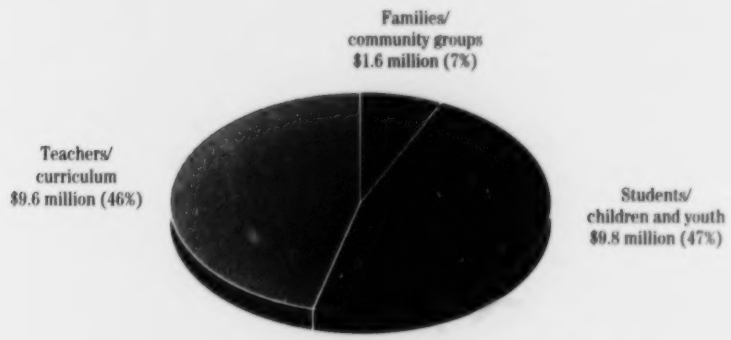
Through these initiatives, the Institute has awarded nearly $21 million in grants since 1992: $10.65 million through the Precollege Science Education Initiative for Museums and over $10.3 million through the Precollege Science Education Initiative for Biomedical Research Institutions. All told, 93 institutions have received awards for programs focusing on students (47 percent), teachers and curriculum (46 percent), and families and community groups (7 percent) (Figure 1).

A principal strategy of the precollege initiatives is to encourage the scientific community to work with teachers, school administrators, other educators, and students at all grade levels. The aim is to stimulate children's interest in science and to improve science education through revision of curricula, improvement of classroom practices, enhancement of teacher education (initial and continuing), and augmented teacher recruitment.

With a major focus on elementary school children, activities funded through these initiatives complement outreach activities funded through the Institute's undergraduate program.

Figure 1

Awards to 93 Science Museums[1] and Biomedical Research Institutions[2] by Program Component, 1992, 1993, and 1994 Competitions ($21 million)



[1]Includes science museums, aquaria, botanical gardens, and zoos.

[2]Includes medical schools, academic health centers, and independent research institutions.

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Eligibility and Award Process

The Precollege and Public Science Education Program makes awards through a variety of mechanisms at the national and local levels. Most awards are made through national competitions, in which selected institutions are invited to submit proposals according to prescribed criteria.

In 1992 a national competition was held for children's and youth museums, natural history museums, and science and technology centers. In 1993 a similar competition added aquaria, botanical gardens, and zoos. For the 1994 precollege awards to biomedical research institutions, applications were solicited from medical schools, academic health centers, and independent research organizations.

In these national competitions, proposals are evaluated by an external panel of scientists, science educators, research and education administrators, and others with relevant expertise. The advisory panel's evaluations and recommendations are reviewed by Institute management. Recommendations are then made to the Trustees, who authorize funding.

In addition to these awards, the Institute has provided support for unique science education opportunities not offered through its national competitive programs.

It also has an active local grants program focused on science education in the Washington, D.C., metropolitan area, particularly Montgomery County, Maryland, the home of its headquarters. Local awards are made at the discretion of Institute management in consultation with the Trustees.

Precollege Science Education Initiative for Museums, 1992–1994

A major goal of the precollege science education program is to provide opportunities for hands-on learning through laboratory experiences and inquiry-based activities. This is now recognized as a necessary component of science education and preparation to teach science. Such learning serves several crucial functions in intellectual development It teaches the student to observe, hypothesize, and develop methods by which to generate knowledge. Hands-on research experiences promote the concept of biology as an experimental science, rather than just something to be learned through lectures and reading. Finally, the collection, analysis, and interpretation of data are best taught by trial and error, with opportunities for modification of experimental design.

The use of laboratories in teaching biology has been declining nationally for many years. Some reasons for this are reductions in school resources for supplies, equipment, and laboratory space; lack of teachers' laboratory experience; and ever-increasing curricular content, with greater demands on students' time. In response to the national educa-

Figure 2

Precollege Science Education Initiative for Museums, 1992 and 1993

- $10.65 million total to 51 institutions
- Five-year awards
- Program elements:
  children and youth
  teachers
  families, youth organizations, and community groups
- Awards
  1992 $6.4 million to 29 children's and youth museums, general science museums, natural history museums, and science and technology centers (162 competing)
  1993 $4.25 million to 22 museums, aquaria, botanical gardens, and zoos (170 competing)

tional deficit, more institutions have opened their laboratories to high school teachers and students, thus offering research experience in well-equipped and exciting environments, with working scientists as mentors to students and partners to teachers.

Museums and related institutions have the capacity to train teachers and assist them in instructing students to develop problem-solving skills and curiosity in settings where they can enjoy learning through exploration. Further, these institutions play significant roles in stimulating parental and communal involvement in the science education of children and youth. Among the activities of particular interest to the Institute are those involving disadvantaged and underserved minority youth and those bringing museum programs to families and youth groups in rural and urban areas with limited science resources.

In 1992 a total of $6.4 million was awarded to 29 science and children's museums for support of precollege science education programs, targeted primarily at kindergarten through 8th-grade children (K–8) and their teachers and parents. The museum initiative supports linkages between science resource centers and elementary schools. It promotes science enrichment activities for children and their parents and enlists the aid of youth organizations, churches, and other community institutions. An additional $4.25 million was awarded in 1993 for similar science education initiatives to 22 institutions, including aquaria, botanical gardens, and zoos (Figure 2).

All told, the science museum program has awarded $10.65 million to 51 institutions, including science museums, aquaria, botanical gar-

dens, and zoos. Of this amount, approximately 53 percent is going to children's and youth activities, 33 percent to teachers and curriculum development, and 14 percent for science outreach to families and communities (Figure 3).

Program Participants

In the first two years of the initiative, about 79,000 students, 3,500 teachers, and over 31,000 adults (family) participated in Institute-funded program activities. Of the teachers, 34 percent were minority and 77 percent women. Of the students, 64 percent were minority and 55 percent were girls (Figure 4).

Most of the participating teachers were at the elementary level (70 percent), and nearly half of the students involved (45 percent) were very young—preK to grade 3—confirming the Institute's commitment to provide exposure to science in the earliest school years. Twenty-eight percent of the children were in grades 4 and 5; 21 percent, in grades 6–8. Only 6 percent were in grades 9–12 (Figure 5).

Nearly half of the children in the museum programs entered through their schools. The remainder generally came directly to the museum. Other venues for museum outreach included community centers, shopping malls, and libraries.

Minority involvement in family-centered programs was 57 percent (Figure 6). Participation often took the form of classes or workshops, or collaboration with teachers and museum staff members in outreach activities.

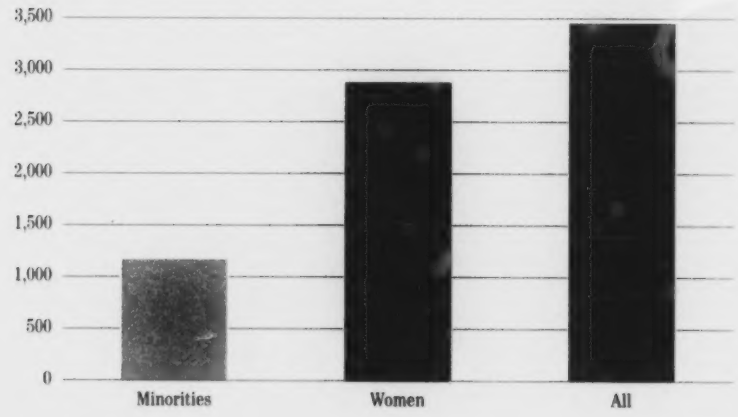
Figure 3

Awards to 51 Institutions—Museums, Aquaria, Botanical Gardens, and Zoos—by Program Component, 1992 and 1993 Competitions ($10.65 million)

Figure 4

Teacher and Student Participation in Museum Program, 1992 and 1993 Awards

Teachers



Students

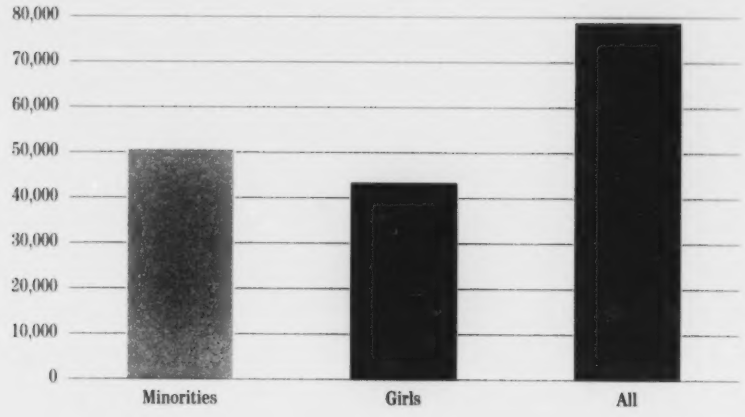
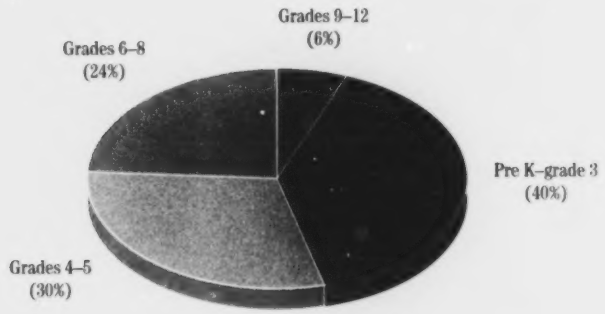


Figure 5

Teacher and Student Participation in Museum Program by Grade Level, 1992 and 1993 Awards

Teachers



Students

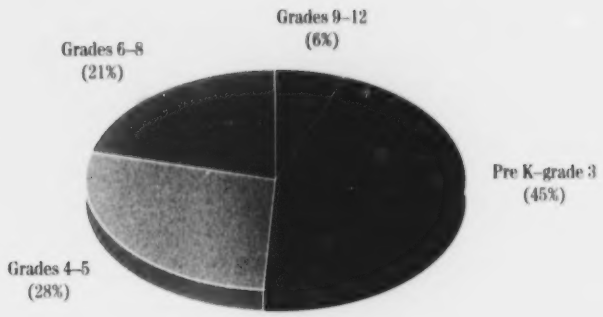


Figure 6

Adult (Family) Participation in Museum Program, 1992 and 1993 Awards

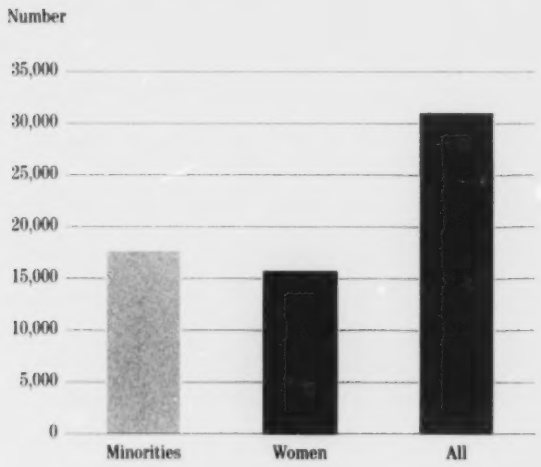


Figure 7

Student Activities, 1993–1994

Activity	Number of Students Participating
Museum visits	42,476
Outreach to schools	35,757
Classes	8,203
Research	1,606
Science clubs	557
Field trips	456
Summer science programs	281
Mentor programs	188
Explainer programs	151
Other	3,526

Student Activities

Student activities supported through the Institute-funded programs can be broad and far reaching or narrow and intensely focused (Figure 7). Museum visits were supported for over 42,000 children during the 1993–1994 reporting period. At the same time, nearly 36,000 students received programming in their schools. Classes provided by museums were available to over 8,000 students.

Older students can take advantage of more long-term, intensive activities, requiring a commitment of enthusiasm and time. Over 1,600 students were able to participate in research programs, and another 557 became members of science clubs. Over 300 students participated in museum programs as explainers or in partnership with mentors.

Summer science programs are increasingly popular. In 1994 students attending a summer science program (either day or residential) for a week or more numbered 281.

Teacher Development and Curriculum Enhancement

The Institute's initiative for precollege science education is intended, in part, to provide opportunities for preservice preparation and in-service training for teachers of biology and related disciplines. Often involved is the development or distribution of instructional materials, with the primary focus on in-service initiatives. Of the $10.65 million, $3.5 million is dedicated to teacher- and curriculum-related activities.

Figure 8

Teacher Development Activities, 1993–1994

Type of Activity	Number of Participants
Short sessions	1,687
In-service	969
Long sessions	398
Summer workshops	180
Preservice	25
Other	240
Total	**3,499**

Teacher development was most likely to take the form of short training programs lasting one day or less. In the 1993–1994 school year, nearly 1,700 teachers took part in such a session (Figure 8). In-service activities are more common than preservice programs. During the summer of 1994, 180 teachers took part in an intensive training program lasting a week or more.

Nearly all of the teachers in the Institute-funded programs participate during the academic year. Teacher training is usually conducted at the museum site (74 percent), and roughly 25 percent is provided through museum outreach to the schools.

Through support from the Institute grants, a significant number of institutions are developing inquiry-based instructional materials and kits, with an emphasis on distribution to teachers working with limited resources in rural and urban environments. In many cases the Institute's grant will enable biology educators to establish and maintain precollege science education programs beyond the life of the grant period.

The most common use of Institute funds for these purposes is for classroom activities—instructional modules that can be infused into standard curricula or provided supplementally. Among the 51 museums, there are 16 traveling exhibits

Figure 9

Educational Materials in Development or Use, 1993–1994

Type of Materials	Number in Development/Use	Number of Users
Classroom activities	347	13,331
Loan kits	83	10,989
Curriculum materials	98	7,336
Traveling exhibits	16	2,903
Videotapes	24	1,442
Guidebooks	12	321
Scripts	33	61
Other	33	15,844
Total	**646**	**52,227**

in development or use. In addition, 83 kits are available on loan from the museum to the classroom. Altogether, over 52,000 individuals—teachers, students, and adults—benefited from these materials in the past year (Figure 9).

Family and Community-Oriented Programs

Recognizing that parental and community involvement in science education will foster young people's interest in science, the Institute designated family and community-oriented science education activities as an important component of the museum initiative. Of the $10.65 million, $1.55 million is for family and community group activities. A variety of exciting approaches draw families, youth organizations, and community groups into the educational activities of museums and related institutions.

Some of the projects offer opportunities for parents and other child care providers—after-school program directors, church groups, Girl and Boy Scout leaders—to be involved in learning science with children. These activities most often take place at the museum (71 percent of the programs), but nearly one fourth of the family involvement takes place at an outreach facility such as a school or community center. Several grants support outreach efforts that bring museum resources to rural families and youth groups with limited science education resources.

Precollege Science Education Initiative for Biomedical Research Institutions, 1994

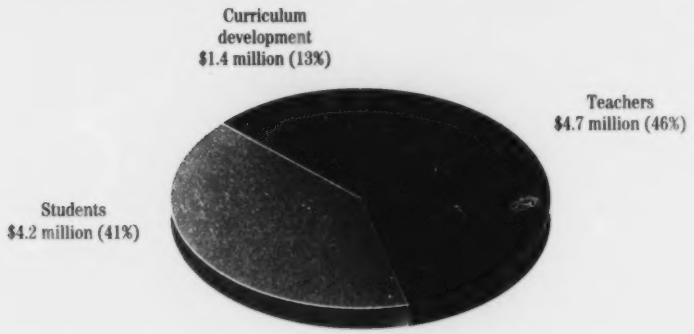
A medical school or research organization is generally viewed by its community as a respected and economically important asset. The faculty and staff include many trained professionals who can influence educational policies and practices, especially as they pertain to preparing young people for future careers in medicine and biological research. In addition, many medical schools are located in inner cities and thus offer opportunities to youth currently underserved in mathematics and the sciences.

With these facts in mind, the Institute expanded its support for precollege science education to include other institutions with a strong potential for science education outreach to students and teachers. The 1994 grants competition was open to medical schools, academic health centers, and independent research institutions. Since the purpose of the initiative was to provide hands-on research experience and science education for students and teachers, eligible institutions had to be engaged in active research, with staff members on site who were willing to give their time and effort to the program. Within an academic health center, research hospitals as well as medical schools were invited to compete.

In June 1994 the Institute announced over $10.3 million in

Figure 10

Awards to 42 Biomedical Research Institutions—Medical Schools, Academic Health Centers, and Independent Research Institutions—by Program Component, 1994 Competition ($10.3 million)



awards to 42 medical schools, academic health centers, and independent research institutions for outreach programs to students and teachers in their local communities (Figure 10). These institutions will support K–12 students and teachers with laboratory experiments, mentoring programs, teacher development, summer science camps, and classroom-based hands-on activities. This newest Institute initiative in precollege science education encourages a larger role for practicing scientists in every aspect of education reform, from textbook development to teacher training.

Of the $10.3 million, approximately 41 percent is going to student activities, 46 percent to teacher development, and 13 percent to curriculum development.

Student Programs

The 1994 grants to biomedical research institutions are supporting programs designed to enhance young people's interest in biology and related disciplines and their understanding of these fields. All the projects encourage the participation of girls and of minorities underrepresented in the sciences. Of the $10.3 million, $4.2 million is dedicated to activities for children and youth. Among the approaches supported are those that engage students, both rural and urban, in afterschool and summer science activities, including educational programs that ease the transition of underserved minority youth from elementary to secondary school. Many of the programs have a mentor component, where students are paired with older students or scientists for aca-

demic and year-round activities. The programs are focused at elementary, middle, and secondary levels.

A number of the funded proposals involve organized collaborations between research institutions and schools. Activities may take place at either site. Examples are field trips, classes, demonstrations, sponsorship of science clubs, and loans of materials and equipment. Another significant focus is on projects that involve students in a variety of research experiments, beginning in elementary school and continuing through the secondary school years.

Teacher Development

The Institute's initiative for biomedical research institutions is intended, in part, to provide opportunities for preservice preparation and in-service training for teachers of biology and related disciplines. Many of the activities funded in 1994 involve creation or distribution of instructional materials and/or teacher development, with the primary focus on in-service initiatives. Several programs provide teachers with practical experiences in research in modern biology that allow them to upgrade their knowledge and laboratory skills. Still others match teachers with scientists for year-round teaching and resource collaborations. Of the $10.3 million, $4.7 million is dedicated to teacher-related activities.

Curriculum Development

Through support from the Institute grants, a significant number of institutions will develop inquiry-based instructional materials and kits, with an emphasis on distribution to teachers working with limited resources in rural and urban environments. In many cases the Institute's grant will enable biology educators to establish and maintain novel instructional tools to introduce students to a variety of biology topics. Programs include curriculum development, workshops and training sessions on use of the new curricula, and dissemination and evaluation activities. Of the $10.3 million, $1.4 million is dedicated to curriculum activities.

Evaluation and Assessment

Each year grantee institutions are required to submit an annual program report presenting both quantitative and qualitative measures. The numbers and types of participating students, teachers, and families are tracked for each grant recipient, and the status of curricular development is assessed. In addition, efforts will be made to determine more subtle, qualitative, and long-term impacts, such as levels of involvement and interest in learning science among families, participating schools, and the general community.

Part I: Proceedings

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Shirley Malcom is head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science. The directorate includes AAAS programs in education, activities for underrepresented groups, and public understanding of science and technology. Dr. Malcom was head of the AAAS Office of Opportunities in Science from 1979 to 1989. Between 1977 and 1979 she was program officer in the Science Education Directorate of the National Science Foundation. Prior to this appointment she was an assistant professor of biology at the University of North Carolina at Wilmington. She also served for two years as a high school science teacher.

Dr. Malcom received a doctorate in ecology from the Pennsylvania State University, a master's degree in zoology from the University of California–Los Angeles, and a bachelor's degree with distinction in zoology from the University of Washington.

She is a member of the board of the National Center on Education and the Economy, vice chair of the Executive Committee, and a member of the governing board of the New Standards Project, as well as the Smithsonian Advisory Council. She also serves on the boards of the American Museum of Natural History, Scientists' Institute for Public Information, Science Service, and the Carnegie Corporation of New York.

She has been nationally recognized for her efforts to improve the education of young women and minority young people by involving community organizations and parents in education reform. She was recently appointed by President Clinton and confirmed by the Senate as a member of the National Science Board and has been named to the President's Committee of Advisers on Science and Technology.

KEYNOTE ADDRESS

Science for All: New Communities and New Attitudes

Shirley M. Malcom

Head

Directorate for Education and Human Resources Programs

American Association for the Advancement of Science

What do I mean by "science for all"? First, it involves the notion of "science literacy," something a number of people are looking at from different angles. Robert Hazen and James Trefil have been looking at content. Project 2061 is identifying what schools must provide in order to produce scientifically literate graduates. Jon Miller and others have been trying to measure current levels of science literacy. But no matter how you look at it, I believe that, as a country, we haven't achieved as much scientific literacy as we would like.

It is difficult to give a definition of science literacy. As the saying goes, I know it when I see it. Science literacy has a feeling to it that goes beyond just understanding formulas, charts, and graphs. By themselves, those don't cause excitement like a news story on a scientific topic when it catches your attention and you want to learn more about it. You want to be able to understand an article about science that's in your local newspaper. You know how to find things out; you know there are sources of information. You have a sense that "I can come to understand this."

So *The Enquirer* Is Wrong: Elvis Really Is Dead?

To be scientifically literate also involves an awareness of the basic values and processes of science. You need to understand the concept of valid evidence to know what information to accept as credible. That credibility also extends to sources. It is important to distinguish among the publications that are widely available, because some are more credible than others. For example, I would put more faith in *Scientific American* than a tabloid such as the *National Enquirer*.

Scientific literacy can also be characterized as a kind of savvy or streetwise condition that one can draw on in any arena or domain—a kind of empowerment that keeps us steady when traveling through difficult content. At the same time, it requires humility enough to see that even when we understand something, there are limits to our understanding, and it involves flexibility enough to accept that knowledge changes when there is new evidence.

Science literacy, then, is so many things that it's hard to put your arms all the way around it. But basically it involves seeing science as a part of our culture as well as a tool for understanding. More than just going to a place and listening to a lecture, science literacy is dynamic, something you can use, something that is part of your life.

The Red Balloon as a Lesson in Value Added

It's terrific to share a love of science with those who value science and who encourage scientific literacy. But it may be even more wonderful to share with those who don't yet realize the importance of science in their everyday lives.

I have a story that I hope you will see as analogous to some of the

issues facing your institutions. It involves the concept of "inclusion" and whether we see things as problems or challenges. In a recent conversation with me, the husband of a kindergarten teacher was raising questions about the benefits of inclusion because of the difficulties his wife was having in her classroom with one developmentally disabled student whose presence was very disruptive. I believe strongly in inclusion but was sympathetic because I also believe that at some point the rule of common sense must kick in and there must be decisions about when it is really appropriate to have students with different levels of comprehension in such settings.

Later that afternoon, I met this man's wife and told her of my earlier discussion with her husband. She said, "A week ago I couldn't have talked to you about Karen [not her real name]. But I can today, because I see so much hope. I think she knows more than she's showing us."

The teacher explained how she was told Karen has a developmental age of less than two years, and she realizes this probably influenced her expectations in the direction of seeing the child in terms of her limitations and the problems she presented. But she started to see unexpected things happening. "We were watching a video based on *The Red Balloon*," she said. "In one scene, there was a picture of a character with his pocket turned inside out, and Karen said 'money.' She knew that was about money!" The significance, of course, is that even many five-year-olds might not make that connection.

The teacher continued with story after story: the trials she had with this little girl and their resolution. As I listened, it seemed to me that this little girl might actually be very bright and that the adults in her life have failed her. Fortunately, that teacher has an opportunity to bring language, and life, and hope—to bring *possibility* to someone who probably would have none of those things, were it not for a kindergarten teacher who is determined not to be put aside even by the most dire circumstances that have been brought before her. In return, that teacher will see greater growth in this particular child than in any other, because the child started from the lowest base. Real value has been added.

The Challenge for Museums

Now what does any of this have to do with your jobs? It would be very easy for all of you who work in the museum community, who are into the business of science literacy, to simply serve the people who show up at your institution. They are fairly substantial in number, and they are people who are ready to be served, who want to be served by your museum. But the focal point of my message—if, indeed, there can be a single point—is that there are other communities out there for which you can provide this same value added; it would be one of the greatest gifts that can be brought to those communities. The challenge is this: How do

Shirley Malcom describes ways to develop a community of learners through partnerships.

you reach people who may not know you are there, and people who, if they know you're there, may not understand that you have something to offer them?

An institution that decides to undertake this challenge must first determine whether it really wants to do it. I once reviewed a museum's proposal for a new initiative for high school students. The institution thought it would be nice to work with this group. But they were not planning to do things differently, not taking any new approaches. If an institution is not comfortable with teenagers, it needs to develop an understanding of what is possible in working with young people and what the young people can bring to the project. The proposal I'm thinking of showed that the museum had not yet achieved this understanding.

Museums need to recognize that serving different kinds of groups may require changes within the institution itself. It may not be possible to serve certain communities, given the way the institution currently operates.

Partnerships in the "Community of Learning"

Different science literacy tools and techniques are available to us, including programs and projects that are school based and school focused. Museums and science centers can become more active partners with schools by going beyond regular field trips and special classes to become purveyors of in-service education. After all, museums are in the volitional learning business; people vote with their feet. If you don't do it right, they don't come. Of course, kids on field trips can't vote with their feet, but their minds don't necessarily have to show up either. The challenge is to bring into the realm of in-service education what you have learned about how to engage and motivate people of all ages.

Some museums bring materials. Sadly, schools are among the poorest places around in technology and resources, and often museums and centers actually bring "stuff." It may not be collection quality, but it certainly is treasured by those who have nothing. This is another kind of opportunity that underpins the partnership with schools.

But the role of museums in creating a "community of learning" takes them beyond their relationships with schools. Museums must connect with those valued colleagues within the community who also have an important role to play. What can such partnerships bring? They bring resources: people, tremendous energy, commitment, political support.

And they can bring challenges.

There are any number of different opportunities for partnership and connection. There are productive partnerships with higher education: faculty contribute to the activities of the museum, consult on exhibitions, and help with decisions about lectures and seminars. I've seen partnerships with nonschool government agencies, such as park or recreational agencies and even juvenile justice agencies that are involved in prevention programs, youth service projects, and housing projects. And I've seen museums become partners with other science-based organizations—zoos, planetariums, botanical gardens, aquaria—when their efforts to help in a community are too big to handle by themselves.

The Community Outside

One of the most difficult partnership issues has been how to reach out to the community that often surrounds the museum. It's not always clear where you start and who you start with. AAAS has cooperated with the Association of Science-Technology Centers in collecting data, and we've discovered a significant number of museums that are actively reaching out to find partners in the community. For example, in a survey of 120 different science and technology centers and museums, over half said they had collaborated with girl-serving groups: Girl Scouts, Girls, Inc., Campfire Girls, etc. They understand there is a difficulty with regard to girls' participation in science, and they're trying to respond by working with groups involving girls and young women. Some have many partnerships; others may have fewer. Of those same 120 institutions, 47 cooperate with minority organizations and programs, 38 with Boy Scouts and boy-serving groups, 37 with public schools. Thirty-three museums are working with community centers, neighborhood centers, and settlement houses in the community, and 24 are with churches. We've been involved in church-based programs for many years in AAAS—in fact, two of our church networks are based in science and technology centers—so we were glad to see that some of our museum partners had picked up on this as well. As the data show, there are significant efforts to identify who is out

there and who can provide a gateway to the community.

Willingness to work with other groups is not the big problem. When we look at the same set of museums, over half of those surveyed had specific strategies and programs to attract girls and young women. Almost 84 percent had some programs or strategies to attract minorities, whatever the minority group happened to be in their own community. And 63 percent had programs that focused on those with disabilities. The problems are related to the nature of the relationships that these institutions had entered into with their surrounding community. Institutions must understand that perhaps it's they that have to change.

Inreach Before Outreach

Museums aren't that different from AAAS, in the sense that we're used to coming in as the experts. We had to learn, sometimes the hard way, that it's a matter not only of telling, but of listening, because there are some things about which the community is much more expert. Such as the routes in, the children served, the ways of engaging, how to connect, what people want to know, what they want to do, and how they want the partnership to work out.

A new attitude is required for you to be successful in connecting with the community outside your door. It requires outreach, yes; but equally important, it also requires "inreach"—looking inside one's own institution at the way business gets done. In some cases the analysis is painful. When analyzing my staff, I ask, Do they look like the community? How are they working in terms of support staff, overall staff, "professional" staff? Is there a role for support staff in helping us to engage with the community?

On the last point, some institutions are beginning to recognize that support staff can provide some of the best insight into the community. And since they also know and understand what the institution is about, they can help make a better match between the community and the museum's offerings. This inreach process also means seeing where different kinds of people work, where they are within the structure of the institution, what the Board looks like. These questions raise issues that are sometimes difficult for institutions to confront.

One of the most important issues is whether visitors to the museum can find themselves in my exhibits. Do exhibits cover topics for everyone? Can visitors find themselves here in the institution? That doesn't mean that each exhibit has to include everybody; but as a whole, the institution needs to offer entry points for multiple constituencies that you want among the audience.

Another piece to this exercise of looking inward involves determining whether you really understand what people expect of your institution. What are you giving the community? What are you providing for different age levels? Has there been an opportunity for members of the community to express their interests and their

desires? How free and open is the outgoing line of communication through which you tell about your institution's offerings?

Tell the Story

Looking outward now, we have to figure out how to tell our story better. Each of you operates a number of programs. How are you measuring the effectiveness of what you're currently doing? How do you measure not only things you can count but also things you can't count? How will you collect the case studies? How will you talk about the new relationships? How will you build bridges that show you're now a new institution, involved in working with other groups to create?

That's the story we somehow have to capture even while in the midst of it all. We need to evaluate, show accountability, show the impact of our efforts. Current support for much of this work comes from people who know that institutions in the business of engaging the public around scientific issues have to do these things. But at some point, the question will be raised, What good have you done? So how do we measure it? Attendance is easy; you count who comes in the gate. But you must also determine whether there is a difference between the population you serve and the population that lives around you. If there continues to be a mismatch, then we have to work harder. And we have to work together to develop new attitudes that will help our institutions come to grips with the communities they want to reach.

I know this sounds like a lot. But in this kind of work, as in every other kind, one gets by with a lot of help from friends. Within any institution, there is an incredible resource base. Here in this room, it is just amazing to think of all that you know and all that you understand. This meeting is your opportunity to share and interact and engage with each other around these really difficult issues as well as many others.

Discussion

Dr. Malcom expressed a number of other views in response to questions and comments from the audience of HHMI program directors. Her comments on various topics appear below.

On Diversity in Institutional Governance. *[In response to a comment that immediate diversity on institutional boards is essential to achieving any meaningful institutional changes . . .]* I agree that we need to introduce diversity, but I don't think that diversity in boards and staffs alone is sufficient to bring about the changes. I have seen institutions that look very traditional do very nontraditional things. Not diversifying doesn't necessarily mean you have an institution that doesn't change.

On Taking the Long View. Wait 10 years, and if [the kids you're reaching today] stay in the community and feel good about the institution, they'll bring their kids. So you're investing in a generation now and you'll see a generational shift when

you get to that point later. . . . I guess I don't have much of a problem with that. I've waited a long time for the world to change. In some ways it has; in other ways it's still the same. But these little steps we make are better than no steps.

We have to invest in this generational change at the same time we are dealing with the immediate. The problem with a total focus on the immediacy is that some changes last only as long as there is outside funding to support them. But the institution doesn't change, and therefore, in the long term, the necessary fundamental and structural changes never materialize. Both are needed. You have to have some shorter-term, more immediate action, but you have to think in terms of the structure of the institution as well.

On Hanging Out, Coming In, Changing Stories to Data. *[In response to a story from an audience member about how his institution viewed it as a problem to have young people "hanging out" in front of the museum rather than an opportunity to invite them in.]* For you, they *are* a problem, because right now they're not a part of the institution. We've got to become much more imaginative about how we engage them. Many museums provide training to young people who become ambassadors, explorers, or explainers—if not in the museum, then in outreach settings in other parts of the community, wherever those young people happen to live. As one example, AAAS has been collaborating with others to train high school students to demonstrate hands-on activities so that they can work with younger kids and become a resource to the community, at the community center or the housing project or in the library that's trying to add a hands-on component. . . .

There are many terrific examples out there. What we somehow have to do is not only collect the examples, but also collect the impacts. Because as individual stories, they are stories. Amassed, they are data. We have to understand the difference between those. . . .

I also hope that we who work on informal kinds of activities can in fact recognize our own responsibility to be a learning community. I'm not just talking about building a learning community but also about *being* a learning community, in terms of trying to figure out how we can measure the effect of what we've done—our impact, how we make a difference—and also how we can replicate something that works.

On Taking the Museum Out. Let's think about the museum as a living entity, not just a place that is housed somewhere. Let's think about the museum as something that can move around in boxes. I know a number of you have those kinds of programs. A box, plus a kid, plus a place equals your museum somewhere else. Is there a way to think about not only bringing people in, but also taking the museum out? I know that this happens with schools, but to what extent does this happen within the larger community?

On the Willie Sutton Approach to Reaching Parents. *[Discussing the difficulty of getting parental support*

for a child's involvement in museum programs . . . / In some cases, they just don't understand what it is that you're trying to do. That's why it's good to partner with groups that already have credibility. You may not have credibility with those parents. You may have credibility in terms of your content; you may not have credibility in terms of being a valued and respected entity they are committed to. You may have to partner with somebody else so that you can share their credibility.

Different things might work. Maybe it's marketing your programs on radio stations the parents listen to; maybe it's having fliers available with heavy graphics, and big letters and small words in the grocery store and the mall. Rather than always requiring parents to come to us, make it more accessible—go to them. I call it the Willie Sutton approach to programming. When Sutton was asked why he robbed banks, he said, "Because that's where the money is." So wherever the parents are, we should go to them and interact with them on their terms. Under those circumstances, they can get to the position where they will let their children come to us.

On the Crisis in Science Literacy. I talk a lot about audience, about science for all and science literacy, and why we want to do any of this in the first place. I happen to believe we are facing a major crisis in this country with regard to science literacy. We're getting to the point where if you can't really take hold of science and technology and mathematics, it's going to be very difficult for you to get a job. At least a job that pays anything. . . .

On Understanding Science as a Process. Science is different things to different people—in part because we haven't been effective in conveying that science is both a process and a body of knowledge. We've done a better job on the latter. But people don't understand why HHMI would want to give money to people to do fundamental research; they don't necessarily understand how this research actually connects to their lives. Some people do, but most people don't. No matter how much we try to say this in publications, in newspaper articles, or other news, sometimes it just isn't a very convincing sell because we haven't prepared people to think about the connection between research application and their lives.

On Cause and Effect: The Bowler's and the Crapshooter's Models of Fate Control. In addition to the need for science and technological literacy in terms of the economy, there is another reason why we need to be able to master the content in a subject area: individual personal empowerment. I cannot imagine what it must be like to live in a world where you do not think there is some relationship between cause and effect, where things are knowable, where they are predictable. Yet many people live their lives like that. There is research that talks about the whole question of "fate control"—there is the bowler's model of life and there is a craps model. Here is the bowler's model of life: "There is something I can do to affect the outcome. I have some

power over my own existence, over my own fate." The craps model of life is: "Who knows—it's all luck, it's all chance."

The question of empowerment is a real question with regard to so many of the kids we want to reach. Can we give them the gift that lets them say, "I have some control over at least this part of my life?" That's one of the gifts your institutions can give through that outreach, that connection.

In talking about science education and the whole question of fate control, some raise the question of whether or not, without a sense of fate control, you can actually engage and become connected to science education in meaningful ways or the converse, whether being able to connect with science education helps give one a sense of fate control in part because it helps you understand what is possible.

[To illustrate, Dr. Malcom related a story about an unusually calm reaction to a pending hurricane by her then-nine-year-old daughter, who ordinarily was terrified of storms.] "We are so lucky that we are studying the weather right now," my daughter told me, because she had learned what to do in terms of safety—board up windows and fill the tubs with water (in anticipation that the electricity was going to go out). She knew there was nothing she could do to influence whether the hurricane was going to hit, but she knew what to do if it did come; she had some control over her actions.

On Partnerships. One of the things that partnerships do is to bring fresh faces, fresh opportunities, fresh insights [to an institution's efforts.] Some partnerships may be with people who are doing cutting edge research and who are trying to figure out how to talk about their work to an audience of people who don't work in that area; some partnerships with other institutions in the community involve figuring out how to work together to provide the right services—for example, you can combine your programs in ways that offer a continuous stream of activity that goes across the different age groups. If the partnership is with entities that haven't a clue about what you're trying to do, and for whom this is the first experience with these ideas, then you realize the importance of the value added by your partnership.

On Preaching to the Choir. I know what I've been saying is a case of preaching to the choir. But sometimes you have to say to the choir: "Sing loudly, sing off the same page, sing in key." That's why it's good to talk about these things together, and not just problems but also what we've discovered.

GETTING STARTED

Big-City Problems and Opportunities

New York Hall of Science

Martin Weiss

In 1993 the Institute awarded the New York Hall of Science $400,000 to train 7th-grade life science teachers in microbiology and provide materials, equipment, and ongoing teacher support. Martin Weiss, biology manager for the New York Hall of Science, described the challenge of working cooperatively with a big-city school board, even for veteran museum administrators.

"It's very difficult to work with such a large group," Weiss said of his interactions with the New York City Board of Education. "There's a natural tendency to say, 'That's not my responsibility.'"

Multiple layers of bureaucracy within the school board created problems for the MICROLAB Institute, a Hall of Science teacher-training program funded partly by the Howard Hughes Medical Institute. School board officials helped launch the program by donating $100,000 for microscopes and other equipment to be used in portable science kits, Weiss noted. But the museum's relationship with the school board quickly deteriorated when former Board of Education Superintendent Joe Fernandez left his post, setting off a mass exodus of subordinates. In the wake of the superintendent's departure, Weiss reported, school board staffers seemed to have little interest in the MICROLAB Institute, which provides microbiology training for 7th-grade teachers.

Because the chain of command within the school board remains unclear, Weiss said, Hall of Science staffers haven't been able to obtain mailing lists of targeted teachers. Information on microorganisms—including bacteria, viruses, protozoans, algae, and fungi—is introduced to New York City students beginning in the 7th grade, Weiss explained. Unfortunately, about one-fourth of all city teachers aren't certified to cover science. Less experienced and bilingual teachers may feel especially uncomfortable discussing microbiology, according to Weiss. But without mailing lists, the museum can't easily identify teachers who are most in need of additional training.

Once teachers are targeted for participation in the program, they must use their vacation time to attend a five-day workshop. Too often, Weiss said, school principals won't use discretionary funds to pay for substitute teachers. Reading-improvement programs, which receive high-profile news coverage, seem to be a higher priority for principals, he added. Teachers earn a $300 stipend but no in-service credits for attending the MICROLAB Institute workshops.

While school principals and board members have demonstrated little support for the MICROLAB Institute, science teachers in New York City face a host of other problems as well. For example, Weiss said, teachers often must move from room to room throughout the school day, lugging science equipment and materials wherever they go. With

only $100 earmarked each year for equipment, teachers are hard pressed to supply adequate study tools. Even if equipment is available, it may be impossible to use, since many New York City classrooms aren't equipped with electrical outlets.

The Hall of Science helped solve this problem by including battery-powered microscopes in portable science kits available for use by teachers who have completed a MICROLAB Institute workshop. Unfortunately, teachers must travel to the Bronx in a private car or taxi to pick up the kits, which can be a hardship.

In the early phases of program planning, Weiss said, Hall of Science staffers developed one-hour workshops designed to introduce school-aged children to the microbial world. But the program was soon redefined to target middle school teachers, since microbiology isn't introduced to New York City students until the 7th grade.

After a one-day teachers' workshop proved too short, several outstanding "teacher associates" were recruited to help develop a five-day workshop focusing on physiology, biochemistry, genetics, and microbial functions. The workshops give teachers an opportunity to collect and maintain microbial specimens and to become familiar with microscopes and other science equipment. Training activities were customized, partly to help teachers "get away from the dominant lecture format," Weiss said.

Graduates of the MICROLAB Institute are invited to borrow science kits. They are also offered "total access" to museum personnel, Weiss reported. During the 1994–1995 school year, the program will expand to offer lectures by microbiologists and other scientists.

Despite its problems, the MICROLAB Institute has been successful. Established in 1991 as an extension of the exhibit "Hidden Kingdoms: The World of Microbes," the program received start-up funds from the National Science Foundation as well as the Institute grant. Program content emphasizes the beneficial effects of most microbes and provides information on a handful of disease-causing microorganisms.

Thus far, the MICROLAB Institute has served 84 teachers. A key to this success, Weiss said, was the decision to work with teacher associates. "When [other] teachers found out that this program had been developed by their peers," Weiss said, "they felt more ownership of the program."

A science advisory committee also provided assistance in crafting content for each MICROLAB Institute, and meetings with museum staff helped bolster internal support. The Hall of Science tried to involve local school superintendents but "got less real support" from that group, Weiss said.

Discussion

During a question-and-answer period following Weiss's presentation, educators like Sandra Kase, a principal in the Bronx, pointed out the impor-

Martin Weiss discusses obstacles he encountered, and overcame, in initiating a large-scale science education partnership between the New York Hall of Science and the New York City Board of Education.

tance of targeting individual school principals rather than superintendents. "You might not be able to reach superintendents," Kase told Weiss, "but principals can help deliver teachers [to your workshops] during the school day."

Since New York City principals are under intense pressure to boost students' reading scores, they might be more supportive if the MICROLAB Institute were more clearly tied to reading objectives, according to a representative of the Montgomery County public school system. Other meeting attendees suggested taking a "sales pitch" into schools to drum up support, instead of inviting principals and superintendents to visit the Hall of Science.

Peter Tirrell of the Oklahoma Museum of Natural History said it might be possible to circumvent the problem of materials delivery by establishing permanent MICROLAB classrooms within schools. Another educator proposed corporate funding to develop a mobile unit for reaching a greater number of teachers.

But Weiss said past experiments with mobile units have shown that they aren't always cost effective or efficient. Also, he added, in New York City corporate funds are being stretched increasingly thin.

Though the MICROLAB Institute got off to a rocky start, it is now providing New York City teachers with much-needed information and materials. "Teachers are hungry for innovative ways of teaching science," Weiss said. "They've been grateful to receive equipment and support through our program."

During his introduction to the presentation by Weiss, Joseph Perpich, HHMI vice president for grants and special programs, noted that bolstering science literacy—through programs for teachers and children—is critical. In a recent survey, Perpich reported, 52 percent of all respondents didn't know that the sun and earth are part of the Milky Way. The good news, Perpich added, is that 69 percent recognized a need to learn more about science.

GETTING STARTED

Working with Schools in a Changing Environment

Arizona Museum of Science and Technology

Charlotte Stromfors and (from the Phoenix Public Schools) Shannon Garcia

Children's Museum, Boston

Diane Willow and (from the Boston Public Schools Science Center) Ann Hamadeh

Moderator

Judy Diamond

University of Nebraska State Museum

In 1993 the Institute awarded grants of $250,000 to the Arizona Museum of Science and Technology and $275,000 to the Children's Museum in Boston to form partnerships with their local schools to create new science programming. Charlotte Stromfors, project coordinator, and teacher Shannon Garcia described their experiences initiating a hands-on program using the desert environment as a content base. Diane Willow, senior science developer, and Ann Hamadeh, director of science for the citywide Boston Public Schools Science Center, discussed a similar approach in an urban environment.

Both the Arizona Museum of Science and Technology and the Children's Museum in Boston are attempting to introduce new curricula and learning approaches under difficult situations. Schools in general are in the midst of philosophical and structural change, and the schools involved in each project are parts of complex systems. The greater Phoenix region has many small school systems, while the City of Boston has one system with 60,000 students.

The two projects started at different rates. The Children's Museum is carefully developing its strategies and identifying likely participants. Museum staff and public school personnel are assessing the particular needs of the schools in preparation for summer teacher institutes that will begin in 1995. The Arizona Museum already has developed and tested a first-year curriculum package for complete or selective use in the 32 regional school districts.

The projects are targeting different specific age groups of students. The Children's Museum is developing programs and materials at the 5th-grade level, the last year of elementary school in the Boston public schools. Based on both local and national research, it is a critical time for the formation of attitudes toward science. In contrast, the Arizona Museum's project is developing curricula for early elementary grades (1–3) to take advantage of the easy access to the nearby desert. The project engages children with the desert just as they are beginning to explore the world beyond their own homes.

Both projects stress the multidisciplinary nature of discovery science. The Children's Museum's Diane Willow described how the discovery process starts with the students' own bodies. After they make observations and measurements about themselves, they will move outward and use the same science process skills to describe and interpret the larger world. As the project continues, it will use the museum's Urban Environment and Education Center, a floating extension of the museum known as the Barge.

Charlotte Stromfors pointed out that desert ecology curriculum materials, the content base of Arizona's Desert Web program, are essential to the "localization" of ele-

Charlotte Stromfors and Shannon Garcia tell how Desert Web familiarizes children in the beginning elementary grades with desert ecology.

mentary science in Arizona. None of the commercially developed elementary materials have a desert emphasis, so Desert Web is an effort to make the early exposure to science germane to Arizona students.

Phoenix elementary teacher Shannon Garcia described how her district borders a mountain preserve, a weekend playground for many students. This resource is now being incorporated into the curriculum through the Desert Web materials. Desert Web is also transferable to other curricular areas such as reading and writing, and has resulted in a change in Garcia's teaching philosophy.

Ann Hamadeh of the Children's Museum described the individual school as the unit of change. Her contribution to the museum's project is to direct the inevitable change in a positive way and to ensure equal collaboration between the museum and the schools. She wants the museum to help the schools define themselves and what they are best able to do in science.

Discussion

During the discussion, the Children's Museum project team pointed out how it is seeking to involve parents in the museum-school relationship. It is well situated to do this, having earned a high level of neighborhood acceptance through intensive work in Boston neighborhoods for many years. Particularly significant is an ongoing program with Latino teens in nearby Lynn, Massachusetts. Lynn Stelmah of the Lawrence Hall of Science pointed out that inviting parents to teacher workshops is an effective way of gaining their support for what is being introduced into the classroom.

Another discussion focused on the relatively nonthreatening position of museums in the community. Rick Guttenberg of the Audubon Institute in New Orleans suggested that parents are more comfortable doing science with their children in a museum setting than in the formal school setting. He recommended

Ann Hamadeh and Diane Willow strive to involve parents in the activities of the Children's Museum in Boston.

that both schools and museums play to their respective strengths, warning that museums, as compared with school systems (especially urban), must be aware of the scale of their activities and projects.

Subsequent group discussion produced the following thoughts:

- museums have more credibility than schools
- are not punitive settings for parents
- can help reduce the isolation of schools
- can help schools provide after-school, Saturday, and summer programs.

There was considerable discussion about the impact of the Statewide Systemic Initiative, the Urban Systemic Initiative, and the Rural Systemic Initiative on the school-museum relationship. Bob Jaskulski of the Cleveland Children's Museum described how difficult it was for the Cleveland public schools to take the museum seriously. It was not until well into the second year of the project that the schools expressed confidence in the museum.

While everyone is a potential stakeholder in the systemic reform process, said Lehman Barnes of the Museum of History and Science, museums must take aggressive advantage of the current opportunity to be included as a significant player. Hamadeh noted the real differences between the ultimate objectives of the various systemic reform efforts. Museums and schools together, she said, must sort out the strengths of the various concerned parties in order to produce the most effective partnerships. Stromfors echoed this, suggesting that the Urban Systemic Initiative school-museum roles are yet to be determined.

The final series of comments dealt with some seeming contradictions in education today. Noting how much effort is currently going into producing a standardized product, Paul Krapfel of Carter House Natural Science Museum cited the National Academy of Sciences' "Science Standards Project," the American Association for the Advancement of Science's "Project 2061," and the

National Science Teachers Association's project "Scope, Sequence, and Coordination." On the other hand, he pointed out, museums are making great efforts to be more accessible to individuals of all learning styles and previous experiences. In the same vein, Dennis Schatz of the Pacific Science Center remarked on the difficulty of reconciling the move toward site-based management with increasingly comprehensive national and state guidelines.

It Takes Two (or More Than Two) to Tango

South Dakota Discovery Center and Aquarium

Terry Lewis and Keley Smith-Keller

Exploratorium

Robert Semper

Moderator

David Goudy

Montshire Museum of Science

In 1993 the Institute awarded $175,000 grants to the South Dakota Discovery Center and Aquarium and the Exploratorium to develop new life-science outreach programs in their communities. Education director Terry Lewis and museum educator Keley Smith-Keller, of the South Dakota Discovery Center and Aquarium, told about forming educational relationships with federal and state entities in their community. Robert Semper, executive associate director of the Exploratorium, discussed the museum's work with the teaching community.

South Dakota Discovery Center and Aquarium

At the South Dakota Discovery Center and Aquarium, collaboration with some of the area agencies has been an effective means of adding expertise to its Institute-funded program. When planning the Discovery Island project, a needs assessment helped to determine where the program should be headed. Networking with federal and state groups uncovered common goals and a plethora of opportunities for collaborative ventures.

Many of the collaborating agencies have scientific staff who were able to enhance the program greatly. The exchange is mutually beneficial because many governmental agencies have small educational departments that do not allow for extensive programs. For example, the South Dakota State Game and Fish Department has only one person to cover the entire state's educational efforts. Participation in the Discovery Center program extends the educational projects of the state agencies, said Terry Lewis.

Keley Smith-Keller, South Dakota Discovery Center and Aquarium, and Robert Semper, Exploratorium, exchange ideas on developing community life-science education programs.

To develop coalitions, Lewis suggests picking the organizations to work with and then beginning at the top. In South Dakota, the agencies were excited about participating, so recruitment was relatively easy. Agencies that agreed to help the Discovery Center would simultaneously receive recognition for their own programs. Furthermore, noted Lewis, to ensure a lasting relationship, partner organizations should help decide how to achieve the best collaboration based on the potential for them to meet their own unmet goals. For the South Dakota Department of Agriculture, for example, the best fit was a program called Agriculture in Science. The U.S. Army Corps of Engineers joined the Discovery Center in the creation of an ecology program. "The value of working with scientists in government agencies," said Lewis, "is that it teaches kids that science is out there in the real world, and their careers are the evidence."

Exploratorium

The Exploratorium program offers a middle school teacher enrichment program, based on the idea of creating a professional home for teachers within an exhibit-based learning environment. The program has been shaped by discussions with teachers, life scientists, life science educators, and Exploratorium staff. Modeled after an existing physical science program, the HHMI project hasn't always been easy. "In talking with teachers, we came across the dilemma of what they need and what they want," noted Semper. "We found ourselves in the position of being both the leader and the follower in this process."

Partnerships can create tension when groups disagree on the direction being taken. Staffing issues have presented a problem for the Exploratorium, as it has not been easy to find the right staffing fit for the program. The program is currently recruiting a person who wants to leave teaching and move toward museum work and has a strong background in biology. Finding someone with those qualifications is the challenge. Refining the curriculum has involved much discussion with partners who had different ideas of how best to cover human biology in the curriculum.

Discussion

What does it mean to collaborate? This question got the discussion rolling and brought a flurry of hands. Participants agreed that the museum community has a lot to offer public education, but emphasized that collaboration is a two-way venture. When museums open their doors, it must be recognized that collaborating groups may approach teaching differently and mechanisms to work through these differences should be in place.

Balancing collaborative efforts is often difficult, said Lewis. "When you start soliciting advice from people, you have to listen, but ultimately you have to be responsible for deci-

sion-making." Participants agreed that if the product is not user-friendly to the teacher and student, it will be rejected. Stephen Essig of the Carter House Natural Science Museum agreed. "You can't just build it and expect them to come. If you can take what you want to teach and connect it with what has to be taught, the program can work."

When it works, collaboration can be mutually beneficial and rewarding. When it doesn't work, the partners can be left wondering what they were supposed to gain from the effort. It can be difficult to recover from a bad experience, and schools and museums, already stretched for time and resources, will be reluctant to try again after a failed attempt. All the more reason, concluded David Goudy of the Montshire Museum of Science, for the expectations and limitations of collaborating parties to be explicit from the start.

Planning and Evaluation

Children's Discovery Museum of San Jose

Roslyn Rubesin-Eigler and (from Gardner Avenue Elementary School) Sharon Banks

New York Botanical Garden

Catherine Eberbach and (from Community School District 9) Sandra Kase

Moderator

Susan Erikkson

Virginia Tech Museum of Natural History

In 1993 the Institute awarded $175,000 grants to the Children's Discovery Museum of San Jose and the New York Botanical Garden for hands-on, discovery-oriented environmental and ecosystem study. Roslyn Rubesin-Eigler, BioSITE program coordinator at the Children's Discovery Museum, and Sharon Banks, a teacher at Gardner Academy Elementary School in San Jose, compared experiences in the first year of their program with Catherine Eberbach, manager of the Children's Adventure Project of the New York Botanical Garden, and Sandra Kase, a Bronx principal.

A number of similarities are evident in the precollege science education programs sponsored by the Howard Hughes Medical Institute at the Children's Discovery Museum of San Jose and the New York Botanical Garden. They share the objective of bringing hands-on experiences in science to elementary students from the surrounding urban communities, and both are using their geographic location as a natural laboratory. However, in the course of comparing experiences in starting up their HHMI programs, members of this bicoastal panel identified several significant differences between their institutions. The categories of differences included:

- the **profile of the institution**, i.e. mission, location, population being served, size of the facility, administrative size, etc.
- **previous experience** with community outreach projects
- the amount of time for the program **planning process**.

According to Rubesin-Eigler, the single largest factor influencing her decision-making and virtually all other aspects of her HHMI program at San Jose was the extremely short start-up time—three months. Working within that short time frame inherently limited the scope of the program, requiring that it be something of a prototype in its first year. This was a familiar situation since the museum itself is young—three years old—and doesn't have extensive experience with this particular kind of program, but they are practiced at starting programs. The pressure of time also meant moving at a fast pace to conduct training and develop materials. But the pressure had beneficial effects. It was easy to sustain enthusiasm and momentum for the program over that short period, and the pressure gave staff a productive sense of urgency.

The picture Rubesin-Eigler painted was one of a command center trying to guide several parallel operations at once, with a team working in unison in a race against time. She described her role as that of a broker pulling together components of existing programs rather than creating a whole new enterprise. The content of the program focused on development of process skills and was based on the state's mandatory science curriculum.

Sharon Banks, a Gardner Academy Elementary School teacher, and Roslyn Rubesin-Eigler, BioSITE program coordinator at the Children's Discovery Museum, describe their first year's experiences with a comprehensive environmental research program in downtown San Jose.

By contrast to the situation in San Jose, the HHMI program of the New York Botanical Garden has its roots in the institution's "master planning" process that occurred over two years, from 1990 to 1992. The actual planning process for the Children's Adventure project began in 1992 with a workshop involving museum staff from science, education, and financial programs, plus a group of international consultants with expertise in similar projects. The staff presence helped maintain a sense of institutional realities, while the outside consultants brought important new ways of looking at things.

The workshop produced the essential structure and goals of the Children's Adventure Project: an "adventure garden," where children would learn about the science of plants and "do real science"; the family garden plots, where children would learn about gardening and nature; and a series of trails and activities that would link the two areas physically and programmatically. One of the most successful links between the two gardens comes from the involvement of economic botanists who are working with community gardeners from different geographical and cultural backgrounds to create and study vegetation from different regions, such as the Caribbean, the Mediterranean, Asia, and Africa.

Both the San Jose and New York programs recognize the need for evaluation, but the degree to which they have incorporated it into the development of their programs has varied in keeping with the nature of each one's start-up phase. The San Jose approach to evaluation tends to be ongoing but informal, given the short start-up time, although Sharon Banks was able to speak extensively with students, whose input was influential in planning the program.

This may have influenced some of the program's clearest impacts. According to the San Jose presenters, these included the fact that participating children developed posi-

Sandra Kase, principal of C.E.S. 42 in the Bronx, and Catherine Eberbach, manager of the Children's Adventure Project of New York Botanical Garden, describe bringing the life sciences to an inner-city school community.

tive relationships with the facilitators, an attachment to the museum, and a sense of having some control and understanding of its environment by the Guadalupe River.

The New York evaluation was fairly extensive. Outside evaluators (the Discovery Group) used focus groups to help assess the views, attitudes, and interests of teachers, students, and parents. That evaluation process, in turn, influenced the program's design, content, and concepts. Catherine Eberbach tells her favorite evaluation story. When asked, "Who does science?" one kindergarten student said with a note of resentment, "The 3rd graders!" Eberbach used this to illustrate that the evaluation uncovered a common view that science is done by "somebody else."

Other revelations ranged from negative attitudes toward plants in the neighborhood to the discovery that teachers tended to know only one particular layer of the subject they were teaching. Interestingly, the evaluation also revealed that people in New York have a literal notion of the "outdoors"—that it is anything outside the house or apartment. Thus, "going to the movies" or "going to the mall" were among their favorite outdoor activities.

Discussion

Several additional themes that emerged from the panelists' presentations and the ensuing discussion are the following:

Doing "Real" Science. At both institutions, the programs are designed for children to do "real science," which Eberbach characterized as using investigatory skills and engaging in the processes of science, as opposed to programs that primarily entertain or involve science-like crafts. In San Jose, "real science" meant observing wildlife with trained facilitators, most of

whom are university students with science backgrounds, and studying the river—measuring its salinity, pH, temperature, and velocity. Rubesin-Eigler said that the State of California doesn't monitor fresh water creeks and rivers, but instead leaves it to volunteers. The students from her program are the first to collect data and monitor the Guadalupe River, which runs through the city of San Jose, so they are having the authentic experience of contributing data and expanding knowledge.

Eberbach indicated that the New York program, in the earlier stages of planning, had been envisioned as something close to *Sesame Street* or something Disneyesque, to serve the goal of drawing families. This approach, however, was strongly rejected in favor of having scientific content at the core of the program.

Program Parameters. Panelists and members of the audience discussed how various initial decisions are made about the program size, scope, purpose, target audience, and length. The underlying factor for all decisions was funding. The amount of money available to administer the program determined the number of students that could participate, within the context of such other determinants as the student-mentor ratio—the length and breadth of the program. In many cases, it comes down to a choice between providing sustained experiences for fewer children versus reaching a larger number for less frequent or less intensive sessions. One participant observed that the decision to do "real science" virtually requires the former option.

"Institutionalizing" the HHMI Programs. There was some concern about sustaining the programs beyond the HHMI funding period. To become permanent, it was generally agreed, a program would need the support of various constituencies, from the institution's leaders, administrators, and scientists as well as schools and community groups. As Sandra Kase noted, this support can begin during the evaluation process, when students, teachers, parents, and others in the community are being consulted about the development of the program. It was agreed that these programs can bring a new audience to the institution as a whole and that, ideally, museums will see these programs as an essential part of their ongoing responsibilities.

On a related subject, there was substantial discussion about designing a program that would be accessible and attractive to parents and families from lower-income communities. Suggested strategies included offering special activities to make parents more familiar with science, setting the program schedule to accommodate single working parents, providing transportation, and collaborating with other groups in the community, such as churches or recreational centers, where parents and families already are involved. More generally, there may be a need to change the institution's image in the community, perhaps through street fairs or other goodwill programs.

ENLISTING THE COMMUNITY

It Takes a Whole Village to Raise a Child

Chicago Academy of Sciences

Janice Siska and (from the Chicago Housing Authority) Lynell Hemphill

Through its 1993 Institute grant for $350,000, the Chicago Academy of Sciences has teamed with the Chicago Housing Authority to offer a long-term science education experience to children and youth in the Henry Horner Homes. Janice Siska, manager of visitor services and volunteers at the Academy, and Lynell Hemphill, director of education and cultural affairs for the Chicago Housing Authority, described the partnership Science Scene: KIDS and TEENS.

Nearly three years ago, the Chicago Housing Authority issued an invitation—and a challenge—to 17 museums in the Chicago metropolitan area. They were challenged to present to the nearly 200,000 people who live in Chicago's public housing, particularly children and youth, quality programs aimed at increasing the odds for entering life outside of poverty and gaining entrance to college. The Chicago Academy of Sciences was the first to come forward with a proposal for Science Scene: KIDS and TEENS, a three-tiered mentoring program that provides in-depth and long-term exposure to science for children and youth.

In discussing the program's birth and evolution, Janice Siska noted that its success relies on the desire of parents and families to make the world a better place for their children. Because participation in the program is long term and, for some, starts early in the educational spectrum, family and mentor involvement is the tie that binds. When resources are scarce, long-term, in-depth programs are labor intensive and particularly challenging.

Lynell Hemphill, citing a long history of promises broken by many cultural and educational institutions to underserved communities, echoed this sentiment: "We didn't want this program to be a part of that history. We know the families in public housing, we know their kids. It would be unacceptable not to persist in making this program work."

The program requires a two-year commitment for teenagers from the Henry Horner Homes, a community of approximately 4,000 residents. To be eligible for the program, the teens need a grade average of C, must have demonstrated leadership skills and a desire to learn, and must garner recommendations from various sources. In addition, parents are interviewed to ensure that they are willing to help their child make the commitment.

The teens spend alternate Saturdays with Ph.D. students at Northwestern University Medical School learning molecular and cellular biology. Robert Goldman, chair of the Department of Cellular and Molecular Biology at Northwestern University, told Siska that the graduate students who serve as mentors see their participation as an honor. To

Goldman, the program serves as an excellent means to recruit superb minority graduate students. In addition, his graduate students learn the very important skill of teaching, one that he says all scientists should learn.

On the other Saturdays and Sundays, the teens work and receive additional training at the museum. Twice a month they conduct science workshops for elementary students and serve as counselors at weeklong summer science camps. Most are paid for their museum work. Others, for whom there are no available paid slots, volunteer. The retention rate in the TEENS and KIDS program has been about 80 percent.

Making the program work has been a challenge, said Siska and Hemphill. In 1994 the pilot summer camp program began with an enrollment of 20 children. In the first week a shooting occurred in the community and parents kept their children home. In week two, only eight children showed up. Siska recalls, "Two years ago, if something like this had happened we would have quit. The odds would have seemed insurmountable." But, added Hemphill, "although we didn't know how to stop the bullets, we could request a police escort for the children." Through a program called Safe Passage, Hemphill lined up a police escort for the bus transporting the children to the museum and requested the establishment of a visible police presence during the program. This was sufficient reassurance for some parents, who allowed their children to make the daily trip to the museum.

Hemphill noted that the program "gives these children a sense of their place in a larger world. Many have never been more than six to eight blocks away from home. The program casts a different light." When asked about the influence of gangs on these children's lives, Hemphill explained that gangs serve economic and social purposes in these communities. "With programs like this, we try to fill in some of the needs currently served by gangs."

Participation in the program requires strong parental involvement and parallel involvement with the schools. Throughout the program the museum makes sure that the schools and parents receive necessary information, that follow-through occurs both at school and at home, and that the educational pipeline stays open for these children after they complete the program. Above all, those involved in the program try to transmit a powerful message to the parents: that their children can succeed and there is a group in the community that will help them do so. Extensive community-based contacts help keep the children and families active and in touch, and an advisory board of community groups helps in recruitment and program direction.

"This is not a one-shot deal," said Hemphill. "We are opening the doors to higher education. Kids who enter the program are promised that they can become TEENS and can then go to college, and if they want, become mentors. This is not a pro-

Lynell Hemphill, Chicago Housing Authority, and Janice Siska, Chicago Academy of Sciences, have helped form a partnership to provide consistent support to inner-city children for science education from elementary through graduate school.

gram to steer kids to jobs after they get out of school. It promises kids college and careers in science."

To make good on that promise, Siska and Hemphill said, a network has been established in the Chicago area to keep the children plugged into the system. Access-2000 (funded by the National Science Foundation), CADRE (Combating Alcohol and Drugs through Rehabilitation), Science Linkages in the Community (supported by the American Association for the Advancement of Science), and the Chicago Urban League are some of the programs that sustain the experience of children wanting to go on to college. In some cases, tuition is provided; in others, scholarship programs are being developed. A local social services agency has been instrumental in helping minority students gain college entrance. The teens receive guidance on taking college entrance exams and completing applications.

The children are not the only group undergoing change. Siska described modifications that had to take place at the Chicago Academy of Sciences to make the program work, such as a series of regular staff workshops and greater awareness of the unique nature of learning in an informal setting. "We had a lot to learn, and still do," said Siska. "A program like this requires two-way exchange, both on-site and off-site." Hemphill reiterated this theme, emphasizing that even the poorest community has something to offer such a program. Both Siska and Hemphill stressed the importance of engaging community insiders in the process to ensure that there is involvement from people who know the politics and people of the community being served.

In discussing the logistics of approaching and working with a housing authority, Hemphill recommended that contacts begin at the executive level on each side and that

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they be direct and open. In addition, each housing development usually has a president and governing structure that must be enlisted before anything can proceed. Furthermore, Siska emphasized, start small. As a program grows and staff learn, expansion can take place. Once a community invests itself in the program, it is willing to donate more time and resources. For example, Siska pointed out, Northwestern University Medical School is so pleased with its part of the program that it has doubled the budget for mentors. The buy-in, says Siska, has to be at the community level. Grants from national organizations can get a program started and give it stature, but sustenance must be obtained locally.

When asked about future plans for the project, both Siska and Hemphill responded, "More students, more partners." Hemphill described an experience she had at a recent national meeting of museums. Upon introducing herself as affiliated with the Chicago Housing Authority, someone responded, "What on earth are you doing here?" Hemphill sees this attitude changing. She already has plans for a new program involving the housing authority and Chicago art museums, modeled on the Science Scene program.

Two Approaches to Science Education in the Urban Setting

Irvine Natural Science Center

Robert Mardiney and (from Northern High School) Maxcine Harbor

Thomas H. Kean New Jersey State Aquarium at Camden

Angela Wenger and (from Coopers Poynt Family School) Bara Franklin

Moderator

Susan McWilliams

High Desert Museum

In 1993 the Institute awarded grants of $125,000 to the Irvine Natural Science Center in Stevenson, Maryland, and $[illegible]0,000 to the Thomas H. Kean New Jersey State Aquarium at Camden. Both programs rely on strong environmental science and ecology themes and target teachers and children in inner-city schools. Robert Mardiney, education director at the Irvine Natural Science Center, and Maxcine Harbor, science department chairperson at Northern High School in Baltimore, were followed by Angela Wenger, education program specialist at the Aquarium.

Rolling green hills and upscale suburban homes provide a backdrop for the Irvine Natural Science Center, near Baltimore. In stark contrast, the Thomas H. Kean New Jersey State Aquarium at Camden is situated in one of the country's poorest urban communities.

Both institutions are training teen volunteers to provide hands-on science activities for inner-city elementary students, but they took different approaches to the problem of reaching urban youngsters. A nationwide volunteer network serves as the framework for a Natural Connections program established by the Irvine Natural Science Center, while the New Jersey State Aquarium is working directly with teachers and other individual educators to implement its Camden Aquarium Urban Science Enrichment Program (CAUSE).

Irvine Natural Science Center

In setting up its Natural Connections program, the Science Center initially tried a "top-down" approach by soliciting support from Baltimore school superintendents, Robert Mardiney reported. Unfortunately, he said, the superintendents wanted a city-wide program, and the Science Center could only provide one-hour science lessons at a handful of elementary schools. "The message we got," said Mardiney, "was 'You're too small for us to take you seriously.'"

Since school superintendents didn't seem enthusiastic about the program, the Science Center sought support from VINE (Volunteer-led Investigations of Neighborhood Ecology). A Washington, D.C.–based organization, VINE provides expert guidance to a dozen member institutions that have established inner-city science education programs across the country. "We get support from these 11 other VINE cities," Mardiney explained.

To make it easier for teen volunteers to teach science with only a minimal amount of training, Mardiney said, the Science Center uses "recipe" type activities. Lesson plans are pulled from an existing Outdoor Biology Instructional Strategies (OBIS) curriculum, developed by the Lawrence Hall of Science. Because the Science Center has

Maxcine Harbor, science chair at Northern High School in Baltimore, and Robert Mardiney, education director at Irvine Natural Science Center, describe Natural Connections, a program for inner-city elementary students, with teen and adult volunteers.

been working with volunteers since its inception 20 years ago, staff members had no trouble recruiting teens to lead elementary science activities during the school year. Also, Mardiney said, "it seemed that the time was right" for the Natural Connections program, since elementary students in Maryland now face tougher state assessment mandates, and high schoolers must complete new community-service requirements.

After checking with other science centers and aquaria in the area to make sure that no existing programs would be duplicated, Mardiney's staff consulted with teachers to identify promising "host sites" for Natural Connections activities. The goal of the program, Mardiney said, was to supplement and enrich—rather than replace—the existing science curriculum. Teachers are generally receptive to Natural Connections activities because they support classroom studies, according to Maxcine Harbor. When teen volunteers are leading the program sessions, she added, teachers have a chance to learn new hands-on activities.

Launched in 1993, the program has already served 644 inner-city elementary students, 114 teen volunteers, and 21 adult volunteers. Thanks to the five-year HHMI grant, it is likely to expand for the next few years. But the Irvine Natural Science Center must ultimately decide whether it wants to pull back and let others manage the program. It might be possible, for instance, to appoint volunteer "site coordinators" at individual schools.

Additional challenges include an ongoing struggle to solve the "logistic nightmare" of shuttling teens to training sites and school yards, Mardiney said. Since Science Center staff members are still viewed by many Baltimore educators as "outsiders," Mardiney is always looking for supportive contacts within the school system.

Angela Wenger (right) of the Thomas H. Kean New Jersey State Aquarium describes the CAUSE program as moderator Susan McWilliams (left), of the High Desert Museum looks on.

Thomas H. Kean New Jersey State Aquarium at Camden

The New Jersey State Aquarium, established two years ago to help stimulate economic growth, is striving to be a key player in the rebirth of inner-city Camden. One of the Aquarium's goals, therefore, is to make its programs increasingly accessible to urban youngsters—especially female and minority students, Angela Wenger reported.

In 1993 the Aquarium used its $300,000 HHMI grant to launch the CAUSE program, which includes a teen-directed summer science camp for elementary students, an after-school ecology club, and a high-school junior staff program.

To get the program rolling, Aquarium staff members first consulted with the city's curriculum coordinator, who recommended individual school contacts. As a result, the Aquarium soon established a working relationship with the Coopers Poynt Family School and the Woodrow Wilson High School. As a "school of excellence," Coopers Poynt must provide students in grades K–8 with basic skills improvement programs. School representatives like science teacher Bara Franklin were therefore very open and willing to cooperate with Aquarium staff members, Wenger said.

Working with teen-aged junior staffers and summer camp counselors was somewhat more problematic. To work with younger students and Aquarium visitors, teens receive training in oceanography, vertebrate and invertebrate biology, ecology, and public relations. This took three times longer than expected, Wenger said. Personal and economic hardships and lack of family support also proved to be stumbling blocks for the teens, she added. For example, one student couldn't complete the junior staff training program because her schedule conflicted with a family vacation.

Next year Wenger hopes to improve family support for teen volunteers by "pulling parents into the program" before training begins.

Matching Program Content with Local Needs

Milwaukee County Zoological Gardens

Mary Thiry and Kerry Scanlan

Pratt Museum

Betsy Pitzman and (from Homer High School) Stan Eller

Moderator

Ismael Calderon

American Museum of Natural History

In 1993 the Institute awarded grants of $200,000 to the Milwaukee County Zoological Gardens and $250,000 to the Pratt Museum for activities involving comprehensive outreach to local schools. The programs reach grades 3 to 8 in Milwaukee and the high school level in Homer, Alaska. Both required intensive initial interaction with the communities. The directors discussed their involvement with the community in both the startup and implementation of their programs.

The Milwaukee County Zoo and the Pratt Museum are both working with their communities to initiate HHMI-sponsored projects. The Pratt Museum is assembling a whale skeleton for display and study in the local high school, and the Milwaukee County Zoo is undertaking an intensive zoo-based biological science curriculum project.

The Milwaukee County Zoo, the largest tourist attraction in Wisconsin, is visited by approximately 200,000 schoolchildren every year. The HHMI project is intended to upgrade the quality of the educational offerings available to those youngsters. This involves further integrating the zoo with the Milwaukee public schools and repositioning it as an educational resource for the region.

The Pratt Museum whale project calls for close collaboration between Homer High School, where the whale will be displayed, and many businesses and citizens in the Homer area. In addition, it encourages diverse connections with the marine environment that is so important to Alaskans.

Milwaukee County Zoological Gardens

The project in Milwaukee started when Mary Thiry, director of educa-

Kerry Scanlan and Mary Thiry, Zoological Society of Milwaukee, discuss the zoo's efforts to become an educational resource for regional schools.

tion, assembled an advisory group of community representatives. Their goal is to help zoo staff determine curricular needs and foster urban Milwaukee's access to its educational programs. Working with the group for a full year proved to be an eye- and mind-opening experience for the staff, said Thiry. First, the variety of ideas and suggestions that came forth made it difficult to focus on the specific issue of science education for the minority community. Second, staff found that they arrived at the process with many mistaken assumptions. Coming to consensus on key issues took far longer than Thiry expected. She pointed out, however, that this was not a confrontational process, but one in which all the participants wanted to be fully understood and to do their best to help the zoo serve the community.

The Milwaukee County Zoo learned from the long series of meetings with their advisory committee that different cultures perceive animals in different ways. This finding corroborates research by Yale biologist Stephen Kellert, who studies the emotional responses of people to various animals under various conditions. The differences reported by the zoo seem to depend on whether people are urban or rural in their upbringing, and are not necessarily a function of racial or ethnic background. Acceptance and general understanding of animals tends to be better developed in rural people, who have greater opportunities, on the whole, to interact with animals at some level. As a result of this, the zoo is developing a more flexible curriculum to accommodate background differences. It is also working on ways to be effectively bilingual.

Thiry pointed out two current outcomes of the program development process. One, it is much more difficult than she expected to get minority female role models to help develop the materials and present the programs at the zoo. Two, the advisory group has been a good influence on the zoo's board, as 40 percent of the Zoological Society's resources are now devoted to reaching the target minority audience.

Pratt Museum

Pratt Museum director Betsy Pitzman reported that the whale project is wonderfully pertinent to Alaska, which depends to a great extent on fishing and tourism. Most Alaskans, both immigrants and natives, live along the coasts, and the native culture is replete with marine symbolism. There is great concern about diminishing populations of once abundant fish and marine mammals and the likely economic and social impacts of such depletion.

Homer High School biology teacher Stan Eller (Alaska's Teacher of the Year) uses the nearby science-rich beach and wharf area as an active laboratory. Field trips by boat are a regular feature. He is taking teachers of art, English, and other subjects on the trips so that the experiences become multidiscipli-

Betsy Pitzman, Pratt Museum director, and Stan Eller, Alaska Science Teacher of the Year, 1994, discuss the Sperm Whale project.

nary and science is seen as an integral part of other human activities.

In its first year, the whale project has already provided opportunities for art studies, for mechanical arts students to design and build equipment, and for science students to work on the anatomy of the blue whale. The project will also be integrated into the economics and history courses of the high school. Finally, it has become a highly visible lesson in volunteerism, from the crews who salvaged and flensed the whale, to the businesses whose trucks and boats transported it, to the citizens serving on the project's advisory committee. Most of Homer High School's 500 students will be involved in one way or another.

Homer's students participated in the selection committee that interviewed biologist Rebecca May, the Pratt project's coordinator. Pitzman believes this experience will be of great help to students as they enter the job market from the other side of the interviewer's table.

Discussion

During the discussion period, a participant pointed out that programs such as Adopt an Animal put common, easily-cared-for animals in school classrooms so that urban youngsters can develop empathy for them. Another discussant, noting the 20,000 children annually served by the zoo, suggested that this subset of users involved in the Institute-funded program be studied carefully with a view to extending their experiences to visitors who see the zoo primarily as a holiday from school.

As one of the few HHMI grantees that work with high school students, the Pratt Museum's whale project is introducing infrequent users to the museum. Although it is based at the high school, the students use the museum's collections and exhibits as resources in a number of their studies. Pitzman is pleased by the environmental and conservation focus that the whale project brings.

She also mentions the recent cuts in Alaskan school budgets that followed the end of the local oil boom. The fact that the whale project brought its own funding and is able to help the high school in some very direct ways made it easier to organize. It is a clear example of an all-around gain, with the museum, the high school, and the entire community benefiting in obvious ways.

Top Down and Bottom Up, Two Approaches to Working with Schools

Audubon Institute

Richard Guttenberg and (from Franklin Elementary Math and Science Magnet School) Ester Stampley

Staten Island Children's Museum

Elizabeth Egbert and Addy Manipella

Moderator

Peter Dow

Buffalo Museum of Science

In 1993 the Institute awarded grants of $150,000 to the Audubon Institute and $125,000 to the Staten Island Children's Museum for the development of formal science education relationships with the local school system. Richard Guttenberg, vice president of the Audubon Institute, and Ester Stampley, principal of the Benjamin Franklin Elementary Math and Science Magnet School in New Orleans, described their collaborative effort. Elizabeth Egbert, assistant director for programs and exhibits, and Addy Manipella, director of museum services at the Staten Island Children's Museum, told how they have collaborated with teachers in the local school district.

Knowledge of the local political climate can be critical when working with schools, since politics can affect the form and functioning of collaborative efforts. The Audubon Institute (manager of the Audubon Zoo and the Aquarium of the Americas), through its understanding of the climate surrounding the New Orleans public schools, chose to go directly to school partners, bypassing the administrative structure of the school system. In contrast, the Staten Island Children's Museum approached the schools by working through the administrative structure of the community school district.

Audubon Institute

The Audubon Institute aims to incorporate the theme of "Building Community" into its programs. According to Richard Guttenberg, the Institute sees the HHMI grant as an opportunity to get reacquainted with its neighborhood. Because there is a real need for after-school activities, the Institute chose to pursue an opportunity to work with schools and students after school in a more concentrated way than is usually allowed in single visits.

When developing the program, Guttenberg approached schools in the neighborhood directly. Principal Ester Stampley agreed to collaborate because the mission and philosophy of her school is based on the same theme as that of the Audubon Institute—Building Community. "What Rick was offering is something we live by every day in our school," Stampley added. The program also offered students the opportunity to go behind the scenes at the Audubon facilities, and see things they could not see on an ordinary field trip.

Including partners in the development of programs ensures that all parties agree on how it begins and operates. "My message is to include us [the schools] at the onset of design so we can plan a program that will work," noted Stampley.

Staten Island Children's Museum

Elizabeth Egbert told participants that the Staten Island program has no animals or collections and is not a

Richard Guttenberg, Audubon Institute, and Ester Stampley, principal of the Benjamin Franklin Elementary Math and Science Magnet School, share experiences in establishing a community science education partnership.

typical museum or science center. Instead, the program relies on artistry and theater techniques to help children learn science. In developing the program, museum staff decided to go in through the district school office because it was the politically appropriate thing to do for their region. Having a good relationship with the schools helped a lot, and working with teachers in the school system gave program planners insight into the needs of all parties. "The teachers in our school district are locked into certain confines constructed by administration," said Egbert. "To ignore those confines would be self-destructive." The museum is free from such constraints and gives teachers a place to experiment and to teach science in new and different ways. Working with the teachers in the program benefits both parties. One group cannot say to the other, "We're the experts," because both groups (teachers and museum staff) are experts.

Discussion

There was widespread agreement that collaborations between schools and museums require constant nurturing and attention. Keeping the primary target (the student) in mind helps to keep things in perspective. Recognizing that all institutions have different cultures and different political systems will make collaborating easier for both parties. Different organizations have different ways of seeing the world, noted Guttenberg. It is also important to keep tabs on the political situations of participating organizations to prevent problems. In this case, ignorance is definitely not bliss.

Planting seeds such as the relationships between schools and museums creates an audience for programs. Programs may be easy to get started but can be difficult to sustain, said Guttenberg. This is particularly important for organizations to think about in terms of funding.

"There has to be a buy-in for these programs so that the community will help you sustain them," said Guttenberg.

It is important to be aware of the demands on the time of school personnel. Participants said it was difficult for school teachers and principals to come to the Howard Hughes meeting, but they agreed that there never was a "good" time. Difficulties aside, collaborations such as the Staten Island and the Audubon program are powerful ones. They demonstrate the importance of working collaboratively and the benefits to be derived from such endeavors.

ADAPTING TO CHANGE

Flexibility and Teamwork Keep Nature Park Moving Forward

Pacific Science Center

Dennis Schatz and (of the Bellevue Parks and Community Services Department) Roger Hoesterey

Through its $225,000 Institute grant, awarded in 1992, the Pacific Science Center has developed and operates several integrated biology education programs at the Mercer Slough, a preserve in a Seattle suburb. Principal target audiences for the program are minority and disadvantaged populations in Seattle and Bellevue, Washington. Dennis Schatz, associate director, Pacific Science Center, and Roger Hoesterey, assistant director, Parks and Community Services Department, City of Bellevue, described their partnership.

"We like to compare our activities to a roller coaster, with its ups and downs and twists and turns," Dennis Schatz said, describing efforts to turn a sprawling wetlands area into a nature park. "It's been an exhilarating ride, to say the least."

As associate director for the Pacific Science Center in Seattle, Schatz has been working cooperatively with the nearby City of Bellevue, which owns Mercer Slough (pronounced *sloo*), a 320-acre preserve covered with slow-moving water. Originally, the slough was part of Lake Washington, before locks were built to lower the lake, transforming the area into a wooded wetlands, explained Roger Hoesterey, assistant director for Bellevue's Parks and Community Services Department. Today the area is believed to be one of the last remaining freshwater sloughs in the country. "It is a tremendous resource, almost within the shadow of skyscrapers," Hoesterey noted.

The City of Bellevue paid millions of dollars to purchase the slough and preserve its natural beauty. A few ranger-led classes and interpretive walks were offered at the site, Hoesterey said, but the city's program "wasn't well defined." Then the Pacific Science Center offered to use its HHMI grant to provide biology education programs at Mercer Slough, including summer youth camps, workshops for families, and school field trips. In exchange, the Science Center asked the city to make the slough more accessible, by providing parking, classroom buildings, and other facilities.

"We wanted the convenience of a suburban shopping mall," Schatz explained jokingly, "yet with the pristine nature of a wilderness area." The city, for its part, was delighted with the idea, Hoesterey recalled. But, he added with a chuckle, officials "did feel that the Science Center was a little demanding."

As the Mercer Slough Nature Park project began moving forward, Schatz and Hoesterey were forced to confront a host of physical challenges and demands. For example, one old building required major renovations before it could be used as a classroom, Hoesterey reported. The relocation of another historic home was complicated by the discovery of lead paint and asbestos tile. A pond had to be constructed to support educational activities, and developers were challenged to build a rea-

Roger Hoesterey, Bellevue Parks and Community Services, and Dennis Schatz, Pacific Science Center, describe their partnership to offer biology education programs at Mercer Slough.

sonably accessible parking lot while also preserving the slough. Finally, a nature trail in the middle of the preserve had to be rerouted to avoid a small strip of privately owned land. Ultimately, development of new park facilities cost the city about $150,000, Hoesterey said.

When the park facilities were finally completed nine months later, the Pacific Science Center discovered a number of flaws in its programming. Staffing requirements, for instance, were greater than expected. Science Center staffers had predicted that the appropriate student/teacher ratio would be 30 to 1. But they soon realized that two teachers would be needed for each group of 30 students. (Schatz is considering various alternatives to overcome this staffing problem, such as working with teen volunteers.)

While the city and the Science Center were grappling with so many physical and programming problems, they also had to learn how to work together without stepping on each other's toes. The city, which had spent between $11 million and $15 million to purchase and develop Mercer Slough, was concerned about receiving credit for the nature-park project, Hoesterey said. Simple tasks such as designing a park letterhead thus became complicated by territorial issues. Program fees had to be reevaluated, too, since subsidized city activities were far less expensive than Science Center activities. Eventually the city and the Science Center began to realize that any problem could be solved, "given the right amount of trust," Hoesterey said.

To be successful, Schatz said, a joint venture such as the Mercer Slough Nature Park must demonstrate four key characteristics. Specifically, he said, participants must share: (1) compatible visions for the project, (2) flexible attitudes, (3) willingness to take risks, and (4) mutual respect. Both the City of Bellevue and the Pacific Science Center are working toward the same vision for a nature park within Mer-

cer Slough. "We wanted a natural setting with diverse flora and fauna, but close to an urban area so that we could access a diverse population," Schatz said. "That was our vision."

In 1994 Schatz and his staff got a quick lesson in the importance of staying flexible when classroom facilities weren't completed in time for summer education programs. The Science Center was forced to "wing it," and find alternate space.

Individuals and institutions involved in a joint venture must be willing to take risks—a proposition that often makes city officials uncomfortable. Finally, partners in a joint venture must maintain an underlying respect for each other, despite day-to-day conflicts, Schatz said. "There were times when we didn't feel [the project] was going to work, but we're now in the long home stretch of that first ride," he said, comparing the project again to a roller coaster. "We have to decide—do we want to do that again?"

During a question-and-answer period following their presentation, Schatz and Hoesterey discussed the difficulty of providing a diverse population with access to a pristine wilderness area. Trails and raised boardwalks allow handicapped visitors to access most portions of the park, Hoesterey said, but some individuals may require assistance to reach a pond area. In keeping with the park's mission to preserve the slough, access to mountain bikes and similar vehicles will be prohibited. Trails have been carefully planned to discourage visitors from blazing new trails through sensitive areas.

The Pacific Science Center is evaluating various strategies to keep its program economically viable over the long term, after the five-year HHMI grant expires in 1997. The City of Bellevue, meanwhile, is pulling together state and federal agencies to construct a new $6 million interpretive site at the slough. Future challenges will include an effort to purchase a privately owned strip of land that separates two sections of the nature park.

Nobody Said It Would Be Easy, but It Certainly Has Been Fun!

Scotia-Glenville Children's Museum

Joan Gould and Ann Sail

Museum of Science and History of Jacksonville

Lehman Barnes and (from Jones Business College and Edward Waters College) Francina Epps

Moderator

Georgiana Searles

North Carolina Museum of Life and Science

In 1992 the Institute awarded grants of $100,000 to the Scotia-Glenville Children's Museum and $175,000 to the Museum of Science and History of Jacksonville to take well-established science education into communities in need of museum expertise and resources. Joan Gould, director, and Ann Sail, education coordinator of the Scotia-Glenville Museum, discussed how the museum adapted to the challenges presented by the HHMI initiative. Lehman Barnes, director of education at the Jacksonville museum, and Francina McSwain Epps, child care director of Edward Waters College, described the second year of the community outreach program.

Scotia-Glenville Children's Museum

The very founding of the Scotia-Glenville Children's Museum, a unique "permanent traveling museum," could be characterized as an adaptation to change. Conceived in the late 1970's, it was originally to have been a traditional museum at a permanent site. At the time, area schools were severely curtailing field trips because of fiscal problems. This circumstance, plus an increased emphasis on hands-on learning in science education, led to the establishment of the museum as a series of traveling programs.

The museum has 25 teachers who deliver more than 35 programs. Joan Gould reported that the museum is using HHMI support to bring biology programs to inner-city schools that otherwise could not afford them. The students involved are in elementary school, and most are from minority and lower-income backgrounds.

For many of the museum's teachers, this was their first experience working with children from the inner city. The museum provided training to help prepare them for the experience. The training was designed in consultation with the inner-city elementary schools and neighborhoods, and included the following elements: workshops featuring speakers from the community; seminars on relevant trends in teaching and learning such "inclusion"; a group visit to the Schenectady Museum and Urban Culture Center; participation in summer parks pro-

Ann Sail and Joan Gould of the Scotia-Glenville Children's Museum discuss the need for flexibility in outreach programs. Moderator Georgiana Searles, North Carolina Museum of Life and Science, is in the background.

grams where the teachers were involved with inner-city children; a workshop on teaching minority children; and a group visit to a city day care center.

Teachers were paid for their participation in these activities. In addition to the substantive knowledge provided, teachers also received some practical suggestions, such as bringing refreshments, because snacks often help hungry children stay focused during the science program. The museum teachers also attended sessions on multiculturalism. Ann Sail reported that one of the strategies they learned there was to have the program developed by a member of the community.

At an end-of-the-year luncheon for the teachers, Barbara Quackenbush, coordinator for enrichment programs for the Albany City school district, described how the HHMI-sponsored activities inspired the children. "They learned by touching and doing things"—which is in keeping with the museum's emphasis on hands-on activities. Sail also indicated that hands-on activities are particularly effective in teaching students for whom English is a second language.

Another change reported by Sail was that the museum became more flexible concerning some aspects of the program. For example, the museum generally limits the number of children to 30 per session; but some of the schools were combining classes in science or social studies, and they asked the museum to provide the program for up to 60 students in some cases. To adapt to this and similar situations, the museum would send two teachers and modify the program for the larger number of students.

The museum offers classes periodically throughout the year in a city municipal center. The year before the start of the HHMI grant, the museum experienced a drop in enrollments for the Saturday morning children's classes. The decreased participation, which was seen at other institutions as well, was a ripple effect of employee layoffs by General Electric, a major employer in the area, because the cutbacks meant a decrease in discretionary funds for many families. The museum reduced the programs from three sessions to two, and developed a class schedule that avoided conflict with athletic programs and the schedules of working parents. The museum also changed its children's programs to family workshops in which parents are more involved, and this change has increased enrollments.

The Scotia-Glenville Children's Museum has an extensive process for developing its programs, which includes detailed research, writing a script, teacher training, and planning and developing hands-on activities and exhibits. Establishing the HHMI program required the museum to recalibrate the pace of its program development activities in order to preserve the quality of its programs. The overall lesson, according to Joan Gould, was that it was better during a time of change "not to do too much in a year, be flexible, and leave the door open to unanticipated opportunities."

Museum of Science and History of Jacksonville

Although the Museum of Science and History of Jacksonville had dabbled in outreach activities previously, Lehman Barnes reported that the HHMI grant made it possible for the museum to develop "Fun STUF" (Science To Unite Families). This is a more extensive family science outreach program for a variety of underserved communities in Jacksonville, an unusually sprawling city where a significant number of children are living in poverty. The informal slogan of the program, according to Barnes, is "families who do science together, stay together." Getting children to have fun with science is relatively easy, he said. The challenge is achieving family involvement, particularly when parents are not present or there are other crisis circumstances.

The Jacksonville Museum developed a number of mechanisms to facilitate family participation: take-home family science activity sheets; evening and Saturday programs; arranging visits to the museum; and taking museum activities to outlying parts of the community that are both geographically and socially different. For example, using HHMI funding, the museum established a small science center in a public housing community for families that would otherwise be homeless. Most parents in the community are single mothers in financial—and often personal—crisis conditions, without a high school education or job skills. It is routine for 100 to 200 children to be involved in the center, but the museum is having more difficulty attracting the mothers, many of whom are young and have a low opinion of themselves as learners.

Lehman Barnes, Museum of Science and History of Jacksonville, and Francina Epps, of Jones Business College and Edward Waters College, discuss enlisting families in science education through Fun STUF.

Another challenge the museum has encountered is keeping a science program going after moving to another church basement, community center, or boy's or girl's club. There are hundreds of potential sites, and the number increases as the museum's programs become more widely known. The museum's approach is to work with the public housing staff and rely on an extensive network of college student volunteers, particularly those majoring in science, mathematics, or elementary education.

Francina Epps reported that the program has been very rewarding for the community and provides a great deal of "value added" for the participating adults and children. Besides spending time together, they also are learning together, doing experiments together, doing

them successfully, and thus experiencing success together. She compared the museum's outreach and hands-on programs with field trips, noting that field trips don't offer the same kind of contact with parents or close adults and therefore don't bring families together.

Discussion

Following the panel presentations, Georgiana Searles divided the audience into three groups that were led by panel members. The groups discussed various challenges they have encountered in establishing and operating their HHMI programs. The following represents the combined wisdom of the groups.

Format and content. Don't include aspects of science that aren't enjoyable; use entertainment to help get people's attention and then offer them education; find out what adults *and* children want in these programs; maintain a balance between instructing and allowing the child to be in control of the learning; provide take-home activity sheets; structure children's visits to the museum to minimize issues of discipline; make the program convenient, inexpensive, and diverse; have fun.

Program delivery. Draw from a variety of alternative sources to help deliver the program, including retired teachers, amateur science clubs and organizations, parents, or senior citizens; recognize that some potential program deliverers, such as scientists, may need training to work with new kinds of audiences.

Publicizing the program. Get out the "word" through schools (including school papers), through libraries, and through advertisements and coverage of events in the public media; hold an open house to which current participants can bring friends; notify employers of parents about family science opportunities; establish contacts with parents at schools and at churches.

Program development assistance. Establish an HHMI clearinghouse for sharing the materials of the HHMI grantee programs; collaborate with other HHMI grantees.

Establishing successful partnerships. Assess the needs and resources of the community and schools; include your partners in planning the program; maintain direct contact with them; identify and draw on previously established relationships among them; be flexible about changing to accommodate them; recognize and validate their role and contributions.

Catching up after a late start. Dissolve difficult partnerships; start over with the parts of the project that are successful, or move the project to a new phase.

Keeping programs going after the museum withdraws. Create a network of teachers who want to continue the program; explore new sources of funds before losing support for the current projects.

Problem-solving networks. Establish advisory boards; maintain routine communication with other museum staff and boards of trustees, in part so that they will be more fully informed about your program if you call on them for assistance.

Evaluation and Assessment: Achieving Science Literacy Benchmarks

Museum of Science and Industry, Chicago

Barry Aprison and Beverly Serrell

Science Museum of Long Island

John Loret and (from Westbury School System) Steven Nordell

Moderator

Robert Jaskulski

Cleveland Children's Museum

Representatives of two programs funded by the Institute in 1992 discussed how to assess needs and evaluate progress. Barry Aprison, project director at the Museum of Science and Industry ($400,000), was joined by Beverly Serrell, a professional evaluator currently employed by the museum. John Loret, director of the Science Museum of Long Island ($250,000), was accompanied by Steven Nordell, a 5th-grade teacher in the Westbury school system.

Museum of Science and Industry

At the Museum of Science and Industry, a new permanent exhibit called Mystery at the Museum uses an interactive program to target visiting students in grades 5 through 8. The 600-square-foot enclosed laboratory space allows students to apply biomedical imaging techniques to solve a mystery. Students' focus is enhanced by using workbooks before their visit and worksheets throughout.

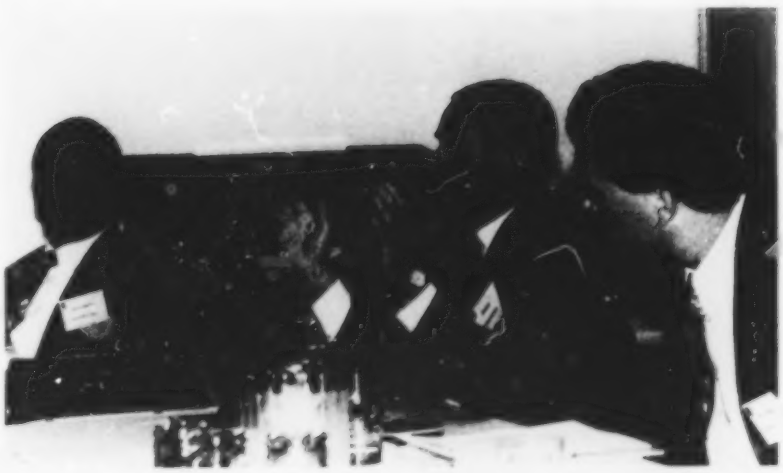
The entire exhibit, Aprison said, has been through various stages of evaluation, particularly during the developmental phase, and it will continue to be evaluated. "How do we know that what we're doing works?" asked Aprison. The Mystery at the Museum program has applied the American Association for the Advancement of Science Benchmarks for Science Literacy for evaluation and assessment purposes. These benchmarks look at factors such as observational skills, teamwork, and awareness of science-related careers.

The Museum of Science and Industry uses the professional skills of Beverly Serrell to assist in the evaluation of the program. With her help, the program expects to achieve about an 80-percent mastery of the performance measures.

Science Museum of Long Island

At the other end of the spectrum in terms of size and type of program, the Science Museum of Long Island has provided science kits and equipment to Westbury schools. The original plan was to have entire classrooms dedicated to the science equipment, but logistical difficulties have prevented this so far. "Despite the problems, the programs have been quite successful and are very popular with the kids," said Steve Nordell. "It's a school district that really needs

Beverly Serrell and Barry Aprison, Museum of Science and Industry, describe their long-range plan for evaluating Mystery at the Museum.



Moderator Bob Jaskulski, Cleveland Children's Museum, John Loret of the Science Museum of Long Island, and Steve Nordell of the Westbury school district discuss their experiences in evaluating outreach programs.

help." Difficulties with the program aside, the scores of the 4th graders on a state-wide science achievement test have shown considerable improvement in the Manipulative Skills section.

The strongest component of the program so far is outreach, noted Loret. The museum currently reaches about 17,000 children each year, at an annual cost of $43 per student. The HHMI science program reached 1,654 students in pre-K through grade 5 in the 1993–1994 school year. The museum is now exploring the use of distance-learning technologies to train teachers. "I believe in exploration and the scientific process, and in exposing kids to this. I think it can really make a difference to them, and our test scores are beginning to show it," said Loret. When dedicated classrooms are available, the effect on test scores could be even higher, Nordell added.

Discussion

A lively discussion ensued on how to incorporate evaluation results into projects. Some participants wondered if feedback mechanisms were handled differently for more capital-intensive projects like Mystery at the Museum: "Is there a 'Gee, this-has-got-to-work' mentality because we've already invested the money in it?" Aprison pointed out that the project had been extensively tested and evaluated even before it was built. Much of the adjusting had to be done up front, he added, and was made possible through mockups of the exhibit and activities.

Those participants who did not come from large museum settings asked how the Mystery program deals with the challenge of making a one-day visit valuable for both student and teacher. They wondered how multimillion dollar exhibit-based projects affect the learning experience. Evaluation, responded Aprison, will continue to help fine-tune the program, with the goal of

enhancing the experience further for both students and teachers. The museum started to use follow-up tools to track students in October 1994.

A similar challenge is faced by the Science Museum of Long Island, because the students do not get daily exposure to the science kits and equipment that the program provides. Many agreed that some exposure is better than none, and museum staff are thinking about having less frequent but more concentrated exposure in future years.

Steepening the Learning Curve—What Are We Learning?

Science Museum of Minnesota

David Chittenden and (from Museum Magnet School) Laura Kindig

Carter House Natural Science Museum

Paul Krapfel and (from the Science in Rural California Program) Stephen Essig

Moderator

Peter Tirrell

Oklahoma Museum of Natural History

In 1992 the Institute awarded grants to the Science Museum of Minnesota ($200,000) and the Carter House Natural Science Museum ($250,000) for multicomponent biological education programs for children and teachers in 4th through 8th grade. Both museums are well into the second year of their projects, and both have altered their initial programs in creative ways to accommodate the realities of their situations. Dave Chittenden and Laura Kindig of the Science Museum of Minnesota and Paul Krapfel and Stephen Essig of Carter House described the program changes they have made in the past two years.

Science Museum of Minnesota

Dave Chittenden began by describing the modifications made in the Science Museum of Minnesota's ambitious proposal after receiving an award that was less than the amount requested. Museum staff used five strategies in order to carry out most of the elements of a multifaceted program.

First, they narrowed the scope. A proposed three-week summer camp at the Museum's Warner Nature Center was eliminated; the project coordinator's position was abolished, with program direction assumed by the director of continuing education; and the project newsletter was reduced in size and frequency.

Second, partnerships were formed with three nearby organizations. The Department of Biological Sciences of the University of Minnesota provided a base for the summer Eco-Explorers (urban ecology) camp, including full access to teaching laboratories. Hamline University and the Minnesota Zoo joined the museum in presenting the Biosciences Institute for teachers by making their facilities available for presentations and field trips.

Third, the museum obtained a supplement to a National Science Foundation grant to provide additional funding for the Biosciences Institute and won a Summer Science Camp grant from NSF to help support the Eco-Explorers camp.

Fourth, the museum integrated its Hughes program elements with several others. The two-week Eco-Explorers camp, which charges no fees, was slightly retooled and offered as a one-week, fee-based camp for the general public.

And fifth, the Biosciences Institute was merged into another, fee-based activity (with HHMI-supported teachers provided with scholarships). In other, less obvious ways the Museum used existing programs and people to implement the HHMI project.

As a result of these changes, the Museum has developed three good partnerships. It is dealing with three times as many participants as originally intended and has extended the impact of the HHMI grants signifi-

Stephen Essig and Paul Krapfel of Carter House Natural Science Museum describe recent changes in the museum's field biology program.

cantly beyond original expectations. While larger numbers are often positive, the Museum is concerned about having less than optimal contact with its HHMI participants (especially the teachers in the Biosciences Institute) and its ability to follow up with the youngsters who participated in the Eco-Explorers camp.

Carter House Natural Science Museum

The Carter House Natural Sciences Museum has also made adjustments, especially in the timing and sequence of its program activities. The filaree exercises are an example of having to take seasonality into account when developing outdoor biology programs. Because the plants have a relatively short annual growing season, adjustments and modifications cannot be made immediately after an experiment.

The museum is also learning about the teachers it is acquainting with participatory field biology. The need for long-term contact with them has become very apparent, and the museum is moving away from short (one-day or several-hour) training sessions to activities that extend over a considerable time, with periods of reflection built into the program.

The museum's work with teachers is being assisted by a collaboration with the NSF-supported Science in Rural California (SIRC) program. SIRC director Stephen Essig pointed out a number of practical issues germane to the Carter House project that are involved in teacher training. These included how to attract and appropriately serve teachers. He mentioned the importance of having the training programs recognize the teachers' personal needs, such as child care, post-training support systems, and sensitive scheduling. He also discussed how training programs can effect long-lasting change. Among his recommendations are: (1) plan backward from desired outcomes, (2) require a team from each site, thus ensuring a

support base at home, (3) require administrators to be present at 20 percent of the sessions, (4) conduct alumni events, and (5) most important, "do it, don't just talk about it."

Discussion

During the discussion period, the question arose as to what can be done to promote continued student participation in museum programs. The group talked extensively about transportation issues, as many of the students that museums wish to reach are dependent on public transportation. Some programs include door-to-door bus or van service, and others give the students bus tokens to encourage attendance.

Attention was also paid to development of a progression of programs that will continuously engage a student for many years. Sometimes such a progression can exist within a museum alone, or the museum can form partnerships with other agencies that either feed students into the museum's program or serve as subsequent sites after the program has been completed.

Another issue that arose was how to entice teachers to participate in museum programs, and much of the discussion was about how to change people who don't want to change. The ultimate suggestion here was to use focus group sessions to find out why individual teachers resist change and what enticements they need to consider new approaches to teaching. The group echoed the SIRC emphasis on teams of teachers and the importance of management involvement in producing an environment conducive to change.

The group also considered the nature and measurement of long-term impacts of museum programs. The group considered the issue of aggregate experiences during an individual's lifetime and the difficulty of assigning particular causality to any single experience. With the understanding that precise identification of any single event as solely responsible for individual interests and capabilities is difficult if not impossible, the group listed the types of evaluation that can be used to determine the effectiveness and impact of a particular program: personal interviews, observations, portfolios, surveys, videos, and long-term program use.

Another topic discussed was the relatively poor integration of mathematics into science activities at all levels. While science programmers refer to measuring, graphing, tabulating, scaling, and comparing as mathematics, the group felt that this was quite superficial and that a mathematician might have a quite different view of the mathematics education being provided. Discussion then turned to the current science reform movements. It was recognized that it takes a generation to accomplish anything, that most innovations in science teaching come from only 5 to 10 percent of teachers, and that some schools and museums, in adopting innovative and forward-looking practices, only lengthen the distance between themselves and those at the poorer, less creative end of the academic spectrum.

Summary of Key Issues

Lynell Hemphill
Roger Hoesterey
Dennis Schatz
Janice Siska
Martin Weiss
Joseph G. Perpich

The presenters for each of the plenary sessions reviewed key points that arose during the meeting and invited the participants to discuss these and other issues relevant to the program.

Community Partnerships

Joseph Perpich, Vice President for Grants and Special Programs at the Institute, opened the session by noting that the changing role of museums in terms of community responsibility has been the topic of much discussion in recent years. As museums take a more programmatic and less curatorial approach to their mission, they have had to reach beyond their walls to establish relationships within their community. Throughout the three-day meeting, attention was often focused on how institutions are shifting their internal focus to education through diversification of staff and boards. As noted by Shirley Malcom in her keynote address, there is a need for "in-reach" as well as outreach, looking inside one's own institution at the way business gets done.

In expanding organizational missions to include community partnerships, museums and related institutions are often entering uncharted waters, and in the words of one participant, "must read the wind." Museums have the capacity to change—unlike school bureaucracies—but in so doing must be a part of the community and aware of local strengths and needs. Museums should be aware of the value-added potential to their programs. Small programs can make a big impact in needy communities and should not be underestimated.

During the meeting one of the discussion groups developed a list of eight questions to be asked when museums, aquaria, botanical gardens, and zoos enlist the community in science education:

- What are we trying to do?
- How do we approach the school system or community group?
- What makes a good partnership?
- How do we define collaboration?
- What does the museum have that the school or community wants?
- What does the school or community have that the museum wants?
- How do we get the principal to say yes?
- How do we relate to the movement for systemic reform?

The Role of Museums in Science Education Reform

The issue of science education reform and the role to be played by museums, aquaria, botanical gardens, and zoos was raised. Numerous associations and societies such as the American Association for the Advancement of Science, National Science Teachers Association, National Research Council, and National Science Foundation have issued standards and benchmarks for systemic reform of science education. Yet the museum community has not been asked to participate in these discussions despite their direct

influence on the educational techniques being encouraged under reform initiatives (e.g., hands-on, interactive learning). In addition, much of the language of reform centers on partnerships and the need for the scientific community to become involved in helping teachers reform the learning environment of the new century. The so-called "informal science education" offered traditionally by science museums is often grounded in partnerships and increasingly so.

Lehman Barnes, Museum of Science and History of Jacksonville, noted that the partnerships now forming between museums and their communities indeed reflect the reform movement. The guidelines and benchmarks being proposed encourage such partnerships because they bring people together to address common goals. They are, Barnes said, forcing people to talk. Even though the "informal science education community" has not sat at the table in this reform effort, suggested one participant, "there is implicit recognition of our strengths in their proposals. We offer a place for reform to occur."

Dennis Schatz of the Pacific Science Center commented that it is often difficult for "informal" science institutions to get taken seriously in systemic reform because museums and related institutions are often not viewed as part of the educational infrastructure. Judy Diamond, University of Nebraska State Museum, responded that the permanence of museums as a part of the community infrastructure (some have been in their communities for over a century) is an asset not to be ignored. Museums can form relationships that go beyond any and all reform efforts.

Several participants concluded that museums can best serve science education reform efforts by doing what they do best, exposing children to science in an exciting and flexible environment. The concept of "volitional learning" and its importance in science education is often best understood and best offered by museums. Museums have the unique capability to bridge the gap between popular culture and school learning and provide a foundation on which children can develop a positive and enduring relationship with science. Lynell Hemphill of the Chicago Housing Authority pointed out that museums can be on the cutting edge of keeping children in a learning environment, especially where the dropout rate is high and school attendance is low.

Finally, conference participants stressed the importance of long-term and in-depth relationships with the community. Jim McDonald, an elementary school teacher in Maryland's Montgomery County public schools, noted that one-time exposure to science through museums will inspire, but not change students and teachers. Museums must work hard at finding out how they can help communities and teachers accomplish their goals. They have become a key element in science education reform.

In closing, Joseph Perpich commented on the diversity of experi-

ences the Institute-funded programs are bringing to students and teachers, mentioning whales, islands, rivers, gardens, and sloughs. He reiterated a theme proposed by Richard Guttenberg of the Audubon Institute, that so many of these programs rely on a three-point partnership of kids, teachers, and their families to promote learning. All of these programs face the common difficulty of determining their effectiveness. Dr. Perpich cited Mark St. John and Deborah Perry's research (page xvi) that asks whether such efforts endure over time, whether they are accessible and adaptable to different contexts, and how such programs are used and valued by the science education community. Museums must learn to evaluate these programs, demonstrate accountability, and show the impact of their efforts. In the words of Shirley Malcom, they must learn to "tell the story. Sing loudly, sing off the same page, sing in key."

Museums and related institutions are an incredible resource, with the potential to change the communities in which they abide. The potential lies in offering children a sense of connection: knowing science provides powerful control over a portion of their lives.

BEST COPY AVAILABLE

1993 Awardees

71 Academy of Natural Sciences of Philadelphia
75 Arizona Museum of Science and Technology
79 Audubon Institute
83 California Museum of Science and Industry
86 Chicago Academy of Sciences
92 Children's Discovery Museum of San Jose
98 Children's Museum (Boston)
101 Discovery Museum–Learning Center
106 Exploratorium
110 Health Adventure
115 Irvine Natural Science Center
119 Milwaukee County Zoological Gardens
123 Missouri Botanical Garden
127 National Aquarium in Baltimore
131 National Zoological Park
135 New York Botanical Garden
139 New York Hall of Science
144 Pratt Museum
148 South Dakota Discovery Center and Aquarium
152 Staten Island Children's Museum
156 Thomas H. Kean New Jersey State Aquarium at Camden
160 Woodland Park Zoological Gardens

ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA

New Eco-Kits Designed to Eliminate Barriers Between Children and Museum Artifacts

Program Director

Nancy Darmstadter

Director of Education

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The Academy of Natural Sciences is a natural history–natural science museum in Philadelphia, Pennsylvania. In 1993 the Howard Hughes Medical Institute awarded the academy $100,000 to produce teaching resource kits and curriculum materials to enable middle school science teachers to introduce object-oriented, inquiry-based instruction into their classrooms. The kits contain natural history specimens, fossils, and other artifacts from the academy's exhibit collection. Curriculum guides accompanying the kits provide lesson plans and suggested activities to promote inquiry and discussion regarding the specimens. The project is directed to middle school teachers and students (grades 5–8) in the Philadelphia area. Real specimens are used to stimulate learning in such topics as animal behavior, biodiversity, life cycles and reproductive strategies, and relationships between animals and their habitats. The lessons are designed to encourage participation by all students, including those who do not thrive in traditional classroom settings.

When he spotted a growling, preserved polar bear display, the little boy could hardly contain his excitement. "Oh, wow!" he shouted. "Look at that!"

"Shhh," his mother whispered, looking nervously over her shoulder. "We're in a museum. We have to be quiet!"

This conversation, overheard in Philadelphia's Academy of Natural Sciences, reflects the challenge now facing many "traditional" museums throughout the country. While glass diorama windows and railings are essential to protect valuable collections, they also establish real barriers between museum artifacts and children. Learning can become a passive activity when children can't touch or smell or handle natural objects.

For nearly a decade, the Academy of Natural Sciences has been helping to remove learning barriers through innovative, inquiry-based teacher training. Most recently, academy staffers began working with Philadelphia-area educators to create 10 museum Eco-Kits featuring natural history specimens, fossils, and other artifacts from its collection.

With help from the HHMI grant, the kits and accompanying curriculum guides are expected to benefit up to 400 teachers and 40,000 students over the next four years. Forty outstanding "lead" teachers will attend a summer science institute and then train their peers to use the

Teacher Ambra Hook of Philadelphia works on plaster casts of "fossils" during a summer teacher institute at the Academy of Natural Sciences, where children learn to work like archaeologists.

Eco-Kits as a tool for enhancing existing science curriculum.

The kits, designed for middle school students in grades 6 to 8, will emphasize a "multidisciplinary approach to biological science teaching," says Nancy Darmstadter, HHMI program director. "Environmental education is inherently multidisciplinary," Darmstadter points out. Understanding the plight of an endangered animal species, for instance, often requires a knowledge of social as well as biological sciences.

Adding Spice to Science Classes

How is a bird similar to a reptile? How is it uniquely different? These are some of the questions children will be encouraged to ask as they work with Eco-Kits featuring mammals, birds, insects, reptiles and amphibians, and fossils.

Throughout their studies, children will be encouraged to consider ecological problems, such as air and water pollution and competition for limited natural resources. Activities such as Struggle for Survival, an endangered species board game, and The Biotic Index, a water quality exercise, will help students explore complex environmental issues.

To help students gain a deeper understanding of each artifact, Darmstadter and her advisers will make use of an innovative approach to science education, SPICE. This method emphasizes five universal "strands," or scientific concepts:

- Similarities and differences
- Patterns
- Interaction and interdependence
- Continuity and change
- Evolution and adaptation.

A close look at reptile skins, for example, might help students understand the organizational patterns found throughout nature—in everything from rock formations to food webs and social groups. An ape's skull could provide clues to its eating habits, and therefore its interaction with a particular environment.

As students work with natural objects in the Eco-Kits, they will become familiar with scientific methods such as observation, data collection and interpretation, and theory development. They will also be encouraged to cultivate an appreciation for natural objects in the kits, which should pave the way for future learning opportunities.

"We've looked at all kinds of interesting and unusual things for use in

Teachers Shirley Hall (left) of Overbrook Elementary School and Jessica Craig of Elverson Middle School discuss mammal skulls and other artifacts slated for use in the museum's EcoKits. Outstanding science teachers were invited to help develop the kits, designed for use by 6th–8th graders.

the kits," says Sean Duran, the academy's exhibits collection manager. "One of the points we're trying to stress is that the object is a very integral part of history. It is our link to information. If we don't protect that object, we lose access to the information it provides. We hope children will learn to enjoy and respect these natural objects at the same time."

To make sure the academy's artifacts are preserved yet accessible to children, they will be presented in special childproof containers such as clear plastic vitrines. Packaging will be provided by The Learning Collection, an educational materials company based in Philadelphia and New York City.

At press time the kits were still under development. A group of 10 outstanding science teachers from Philadelphia were invited to help refine the kits, based on sample activities prepared by Darmstadter's advisory committee during a summer teacher institute in August. "We decided to capitalize on the teachers' experience," Darmstadter explains. "We wanted the process of developing the kits to be the same as the process of engaging the students using the kits."

Also during the August workshop, participants were asked to "test-drive" the Eco-Kits with help from the academy's Carver summer explorer camp students and other teens. "That's so important," says program adviser Deborah Bambino, a teacher in Philadelphia's Central East Middle School. "No matter how long you've been teaching, you never know what students are going to come up with until you try something out on them."

A History of Innovation

The academy was founded in 1812, and its education department in 1932. With a staff of approximately 280 people, the academy conducts

basic and applied research, maintaining a collection of 20 million specimens and artifacts. Its library, located in Philadelphia's historic Logan Circle district, contains 157,000 volumes and 3,287 periodicals.

The academy's education department has a long track record of working closely with the local public school system. Darmstadter previously developed such innovative programs as the academy's Creative Science Teaching workshops. Training sessions have covered a variety of topics, from Native American Ecology to Digging for Dinosaurs.

By targeting middle school teachers with the Eco-Kits program, the academy hopes to reach youngsters at a critical juncture in their academic careers, says Jim McGonigle, the academy's director of watershed programs. "We latched onto students in middle school because that's when they start deciding what track they want to be on," McGonigle explains. "If you can get them interested in science at that point, there's a good chance for achievement in their future studies."

Methods for evaluating the success of the program have not yet been established. Darmstadter points out, however, that each kit will include a set list of learning outcomes and focus questions that may be used to determine a child's progress. "We haven't identified any formal assessment tools," she says. "But children should be able to answer focus questions like 'What makes a bird a bird?' and 'How is it different from or similar to a mammal?' This would be a pretty straightforward way to assess their progress."

Teacher Deborah Bambino expects the Eco-Kits to remove some of the barriers children may encounter in traditional science museums. "I really think they're going to be able to see themselves as scientists," she says. "I also hope the kits will help them see the museum not as this dead, cold place they might visit once a year, but as a source of vital information they can tap into."

Institutional Profile

Annual attendance	282,271
Annual budget	$2,284,543*
Annual education budget	$643,745*
Endowment	$22,334,365

**Museum only.*

ARIZONA MUSEUM OF SCIENCE AND TECHNOLOGY

Desert Web—Using the Local Environment

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The Arizona Museum of Science and Technology is a science-technology center in Phoenix, Arizona. In 1993 the Howard Hughes Medical Institute awarded the museum $250,000 to create Desert Web, a five-year interactive science outreach program for minority and disadvantaged children, including students of English as a Second Language. The program uses the interactive approach to science through teacher workshops that include curriculum guides, and hands-on activities and materials consistent with the existing curriculum of 1st- to 3rd-grade students in targeted school districts of the Phoenix area. The program uses desert-related sciences to encourage students to question and investigate the world around them. Grade 1 explores the biological and physical components of the desert. Grade 2 focuses on animal and plant adaptation for life where temperature extremes exist. Grade 3 explores plant and animal adaptation to an environment where water is scarce. Participating teachers will receive 16 hours of initial workshop instruction with materials and curriculum guides, and 2 hours of subsequent workshops.

Phoenix is surrounded by desert—lots of desert. The Arizona Museum of Science and Technology, with the assistance of the HHMI grant, is developing curricula that take advantage of this prominent local resource. As the museum introduces inner-city Phoenix children (six urban districts) to a nearby environment that many have never visited, it simultaneously reintroduces reservation children (such as those at the Chinle Elementary and Salt River Day Schools) to the nature their parents fear they are ignoring in favor of TV and videos.

Project coordinator Charlotte Stromfors' research during level 1 (1st grade) curriculum preparation revealed several local issues that Desert Web is trying to accommodate. Cutting across all districts is concern about the appropriateness of curriculum packages for the desert Southwest. Teachers uniformly observe that while their district is committed to teaching about Arizona's own unique ecosystem, the classroom materials with which they must work include "descriptions of ponds and large green trees, items that are not part of our arid landscape," notes Stromfors.

A particular concern expressed by Ted Fadler, principal of Chinle Elementary School (on a Navajo reservation with a 100-percent Native American student body), is that today's students have lost touch with the land that is so important in

Teachers develop hands-on experience in the biological aspects of the desert through Desert Web field experiences.

traditional culture. Thus, he and science curriculum coordinator Gloria Means are particularly interested in Desert Web.

Early Content Development

When the project was still in its formative stages, the museum took advantage of its existing relationship with Phoenix's Desert Botanical Garden and the Phoenix Zoo. The Botanical Garden has extensive experience in research and horticulture of desert plants and ecosystems. Stromfors visited garden education programs and worked with garden educator Kathleen Socolofsky to develop ways to bring desert ecology to early elementary students.

Socolofsky notes, "We have a pretty good handle on desert ecology and environment and are able to share that content expertise with the museum. Charlotte is really open to new ideas and is adapting some of our materials to her K–3 programs. This joint work is an excellent experience for both institutions; each of us is becoming stronger as a result. But it's still too early to speak to the ultimate quality of the materials."

Judy Atkins, a 1993–1994 Christa McAuliffe teacher at Scott Libby Elementary School in the Litchfield District, has been serving as an adviser to Desert Web. Her expertise on desert ecology and children's activities (she is developing a 20-acre outdoor environmental education site at Scott Libby) is invaluable to the project. Not only does she bring a teacher's perspective to the work, but she is also making her environmental project available to teachers in the entire Phoenix region and the state of Arizona. She notes that Desert Web is one of the programs that is helping to unite the smaller outlying school districts, those that do not have the extensive resources

BEST COPY AVAILABLE

Teachers take their field experiences into the classroom during teacher workshops.

available to some of the city and suburban districts.

As a self-admitted museum junkie who regards a science museum as the center of a community, Atkins hopes that "Desert Web will be a model for desert awareness and an example for teachers who want to use hands-on methods." She notes that Arizona children can name dinosaurs but not the local cacti. "It's time to change that and learn what's special about our place."

The Real World

Once the grant was announced, the museum staff realized that organizing the project would be more difficult than they had initially thought. By the time Stromfors had been hired and got started in the fall of 1993, a number of teachers who had initially expressed interest had lost that interest, been reassigned, or for other reasons could not participate. After a lengthy round of meetings with individual teachers and with the curriculum coordinators of the Greater Phoenix Educational Management Council (17 districts), three new schools and 10 new 1st-grade teachers joined the program.

Examination of the settings in which the Desert Web curriculum will be used also introduced some new issues. Arizona school districts are markedly independent, making scheduling and age- and grade-grouping decisions at the local level. There is a patchwork quilt of schedules, philosophies, and organizational styles.

Stromberg discovered several variations in the organizational structures within the region's schools:

- Classes range from nongraded (multiple grades combined) to graded (single grades) to multi-aged (no grade designation).
- Some teachers follow their students from 1st through 3rd grades, and some do not.

- Some schools have site-based management, and some have districtwide management.
- At some schools 100 percent of the teachers for some grades are enrolled in Desert Web, while at others gradewide participation is more limited.
- Academic-year calendars and vacation schedules vary greatly.

This independence and diversity pose a challenge for Desert Web. "We have to be creative as we develop our curriculum," says Stromfors. "It has to be geared to each school's structure and needs, but must also be usable by all. We are going to index the science education activities according to Arizona's Science Essential Skills. Then each teacher will be able to pick out those skills and activities that are most important."

Vital to the Desert Web curriculum is that it be region-specific. Teaching about Arizona's desert plants and animals is a major goal of all elementary teachers, but the commercially available science materials are not focused on Arizona. The museum's good relationships with the Desert Botanical Garden and the Phoenix Zoo will sharpen this aspect of the program.

Level 1 Completion

The level 1 (1st grade) curriculum has been completed. It emphasizes the biological aspects of the desert, with a focus on the physical properties that underlie the desert ecosystems. Students will explore subjects such as the effect of intense sunlight on desert life, the benefit of shade, and the properties of dry, sandy soil. Activities include environmental games and role playing to bring out components of desert ecosystems, nature walks, and foods derived from such desert plants as mesquite trees and cacti.

The preliminary product was reviewed by two teacher focus groups in June 1994. Laura Martin, director of education and research, assisted these groups. The teachers had seen the level 1 curriculum in advance and were able to discuss the planned activities. While there were a number of suggestions for changes and improvements, the reactions were positive. In fact, many of the teachers are looking forward to the completed product with great anticipation.

Since the June evaluation sessions, the museum has responded to the critiques and is presenting teacher workshops based on the revised curriculum. A final version of the curriculum was planned for classroom distribution at the beginning of the 1994–1995 school year.

Institutional Profile

Annual attendance	100,000
Annual budget	$1,500,000
Annual education budget	$176,000
Endowment	$22,000

AUDUBON INSTITUTE

Better Living Through Science

Program Director

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The Audubon Institute is an aquarium, botanical garden/arboretum, natural history–natural science museum, and zoo in New Orleans, Louisiana. In 1993 the Howard Hughes Medical Institute awarded $150,000 to the Audubon Institute to conduct FUN–SCIENCE!, a yearlong life science immersion program for upper-elementary public school students. The program offers experiential science education for 540 children from two neighborhood schools. The majority of the students represent minority groups typically underrepresented in the sciences. The program also includes professional development activities for classroom teachers at participating schools and a family component for adult role models to engage in science activities with their children. FUN–SCIENCE! explores life science concepts of ecosystems, adaptation, reproduction, growth, and development through the overarching themes of survival, species interdependence, and conservation. Working closely with zookeepers, aquarists, curators, researchers, and technicians, students experience first-hand the tools and practice of professional science.

Audubon's Place in the Community

The Audubon Institute has its roots firmly planted in the community. Its impressive attendance record attests to its popularity. The city of New Orleans has a population of a half-million people, and the zoo and aquarium facilities attract upwards of two million visitors per year.

"We draw visitors from all over the metropolitan area, and we take very seriously our educational mission to those visitors," says Richard Guttenberg, vice president for educational programming and coordinator of the project at the Audubon Institute.

With the area's strong ties to outdoor activity and ecology, the Audubon Institute figures prominently in New Orleans civic life. Its reputation and standing with the community, its proven track record with science education, its accessibility to local schools, and its experienced staff make it well suited to initiate the proposed program. "This program gives the Audubon Institute the opportunity to be a good neighbor," remarks Guttenberg.

Connection with the Area Schools

"I have been waiting for this kind of opportunity to connect with our local schools," he says. "When we first approached the principals and the parents about this idea, there was a lot of interest, and a consensus

DAVID BILL, AUDUBON INSTITUTE

Empathy and enjoyment are important components of learning in after-school science sessions at the Audubon Zoo.

emerged that we would do an after-school program. Increasingly, after-school hours are being spent less and less with families, so there is a need to make this time both meaningful and fun," he adds.

Access to resources like the Audubon Institute program is sorely needed. Students in the Louisiana grade school system rank near the bottom nationally in scholastic science and math performance. Public school students in New Orleans, who lack adequate science instruction, score the lowest in the state.

"Schools in New Orleans are desperately poor," says Guttenberg. "I cannot convey the dire situation of the schools in words." The scarcity of resources and qualified science teachers is felt severely in the sciences and mathematics. As a result, many students never gain an interest in science.

"Louisiana is an incredibly resource-rich state that requires workers to have competency in the sciences," says Guttenberg. "We need students to come out of our school system with an understanding and appreciation of science and math. The Audubon program reaches children in preadolescence, a developmental period that is crucial to the child's future interests."

Program for Children, Teachers, and Families

FUN–SCIENCE! has components to reach children, their teachers, and families. Students from participating schools will come to the Audubon Institute on a regular basis for learning sessions that use the existing resources of the zoo and the aquarium. Teachers from the participating schools will be provided professional development programs and will be involved in curriculum development. Families will have opportunities to participate in science-learning activities on weekends and holidays, including the summer months.

DAVID BULL AUDUBON INSTITUTE

Curiosity and structured access to the natural world lead these young entomologists down paths blazed by famous predecessors.

In the component for children, the program will integrate experience with the naturalistic environments at the zoo and aquarium with an exploration of life science concepts of ecosystems, adaptation, reproduction, growth, and development. Overarching themes of survival, species interdependence, and conservation will be woven through the program.

Staff from the Audubon Institute (e.g., zoo keepers, aquarists, curators, researchers, and technicians) will work closely with the students. The tools and practices of science will be conveyed from staff to the students through the students' first-hand experiences. Zoo and aquarium staff will be involved in developing the curriculum and the supporting activities. Program activities will also be coordinated with the school-year program.

The children's interest in the zoo and aquarium will pave the way for their involvement in the program's scientific activities. Students will learn to use tools such as microscopes and water analysis kits, and will be able to gain an understanding of the plants, animals, and waterlife that would not be possible on a single visit.

Teachers from the participating schools will be offered professional development opportunities through the new program. A faculty orientation will introduce teachers to its objectives and activities.

Teachers will use this information to integrate and reinforce the FUN–SCIENCE! curriculum in their own classes. Teacher workshops will provide life sciences material for their use. Leadership training opportunities will aid in recruitment of new teachers.

"I am so excited about this program," says Dan E. Davis, who teaches the upper-elementary science curriculum at McDonough #15 Creative Arts Magnet School in the French Quarter of New Orleans. "This will take us from a very dry, book-oriented curriculum to one that

is hands-on. I don't think books should ever be the central focus of teaching, because hands-on activity is what keeps kids interested."

Families of the students will be involved through both the curriculum and periodic events. "We need a three-point partnership of kids, teachers, *and* their families to really promote learning," says Guttenberg. "Schools are not always set up to promote parent-child interaction, so we have a wide array of participatory programs for families." The curriculum will provide kids with an understanding of how science relates to their everyday lives, involving families as supervisors, subjects, and participants.

The Program Is Taking Shape

"We are staffed and our curriculum development is under way," says Guttenberg. Working relationships with the four participating schools have been fostered, and advisers from local universities have been convened to discuss the curriculum, which was piloted in the summer of 1994. An early 1995 implementation is being planned.

Institutional Profile

Annual attendance	2,348,755
Annual budget	$21,070,000
Annual education budget	$1,350,000
Endowment	$5,000,000

CALIFORNIA MUSEUM OF SCIENCE AND INDUSTRY

Children Understand Human Health Through Your Insides Out!

Program Director

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The California Museum of Science and Industry is a science-technology center in Los Angeles, California. In 1993 the Howard Hughes Medical Institute awarded the museum $175,000 to provide, for present and future exhibitions, a comprehensive educational program supportive of its increasingly diverse clientele of children, families, and teachers. To achieve its goals, the museum has formed a partnership with the Los Angeles Unified School District and the University of Southern California. Through two collaborative programs, the museum expects to reach over 40,000 children (in grades 1–6) and adults each year. Your Insides Out! emphasizes hands-on activities and experiments in human biology. Science Comes Alive! is an established interactive assembly program addressing more complex physiological problems through probing questions, stage props, demonstrations, and role playing. In-service workshops focus on increasing knowledge and thematic understanding in life sciences while exposing teachers to activity- and inquiry-based learning techniques.

Bringing the Life Sciences to Los Angeles

With the Institute grant, the museum is working toward its goal of developing a comprehensive life sciences program. The strategy is to enhance both formal and informal education in the life sciences for schoolchildren and teachers.

Building on its previous success with programs that create learning opportunities through hands-on activities, the museum is developing Your Insides Out!, a program that provides children the opportunity to participate in hands-on workshops in different rooms at the museum devoted to the various organs of the body. "The program allows us to teach kids specific issues related to how the human body works," says David Combs, science curator.

Science Comes Alive! was started in 1992 to provide children with interactive assembly programs on human and animal biology. Participating children may find themselves acting out a pain reflex to help understand how the nervous system sends messages, or discussing acquired immune deficiency syndrome (AIDS) after visiting an AIDS exhibit. It allows complex physiological concepts not easily taught with a quick hands-on activity to be conveyed to students, using stage props, demonstrations, and role playing.

Situated within the nation's second largest metropolitan area, the museum reaches a large, diverse audience and welcomes over two million visitors annually. The Los

Learning to measure blood pressure at the California Museum of Science and Industry.

Angeles Unified School District, with over 30,000 teachers serving approximately 625,000 K–12 students, enrolls school children from 84 different language groups. Minority students form a high percentage (nearly 80 percent), with many living in poverty. The museum understands the importance of engaging women and minority students in science and has a proven track record in developing programs with this goal.

Los Angeles School District budget constraints have hampered teachers' ability to offer quality science education. Under these challenging conditions, teachers have been given a new state science curriculum mandate that guides teachers in presenting a more thematic and integrated approach to science. The partnership between the schools and the museum offers Los Angeles teachers some much-needed breathing room and a chance to give students hands-on life science education.

Teachers must have comfortable ownership of the content, tools, and teaching methods necessary to make a change in life science education. "We want to address the teachers' needs as well as the students'. We'll be doing workshops that give teachers knowledge and thematic understanding of the life sciences. Then we'll give them the tools and written materials for doing hands-on science in the classrooms," says Combs.

Teacher education activities began in earnest in the fall of 1994. The University of Southern California, another partner in the project, will provide important aid to the museum through faculty participation.

The museum is well poised to develop the life science education program, having conducted a variety of educational activities for 30 years.

For example, Science Workshops provides major scholarships for low-income families, research laboratory experiences for high school students, and a docent-led traveling museum available to schools throughout the state.

Learning About the Human Body

Your Insides Out! will be housed in the Kinsey Hall of Health, with work areas for up to 16 students at a time, in an atmosphere that clearly evokes the subject matter. "The program will introduce specific conceptual issues about how the human body works by having the kids do a variety of things that will connect the concept with their own body," says Combs.

With large photographs by Lennart Nilsson as a backdrop to their activities, students work at tables shaped like a body organ (heart, lung, kidney, brain).

A real specimen of the human organ is on the table. Activities related to the respiratory and cardiovascular systems are being developed and will have students measure their own blood pressure, heart rate, and lung capacity. Just as important to the experience will be helping children understand the importance of the variables being measured.

"Real life" health science tools go a long way in teaching children and adults about how their bodies work. Electrocardiogram readings, for example, will give them a computer printout of the electric signals that cause their heart to contract. So far, the process has revealed that some of the proposed activities may be too complicated for younger children. While older children may be able to measure blood pressure with a sphygmomanometer, younger children may do better just focusing on the measurement of heart rate with a stethoscope.

Sitting at the "brain" table, a visitor measures his pulse during a trip to Your Insides Out.

Your Insides Out! workshops were scheduled to start in the fall of 1994. Plans are to adapt the exhibit for family use on weekends. Staff tested activities with groups of children. Response to the activities has been positive, and they are quite popular. This pretesting will help refine the program.

Institutional Profile

Annual attendance	2,000,000
Annual budget	$8,800,000
Annual education budget	$680,000
Endowment	none

CHICAGO ACADEMY OF SCIENCES

Role Models Creating Role Models: The Scene at the Chicago Academy of Sciences

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The Chicago Academy of Sciences is a natural history–natural science museum in Chicago, Illinois. In 1993 the Howard Hughes Medical Institute awarded the academy $350,000 to develop Science Scene: KIDS and TEENS, an outreach program that aims to enhance biology and ecology education for disadvantaged minority teenagers and children. Combining the resources of the academy with those of Northwestern University Medical School and the social service resources of the Chicago Housing Authority, Science Scene creates an environment conducive to science learning and inquiry. Informal workshops in science education are offered to 5th- and 6th-grade students from a nearby housing development, and Northwestern medical students provide mentoring and instruction in cellular and molecular biology to economically disadvantaged teens from the Chicago public schools. Science Scene uses mentoring to build self-esteem, hands-on experiential learning to generate natural curiosity, and family and teacher involvement to create a supportive environment.

Elementary school students in Chicago's public housing communities are being connected to students in a medical school via city teenagers who are learning and teaching about biology and ecology.

Science Scene: KIDS and TEENS is a precollege outreach program developed by the Chicago Academy of Sciences, a science museum that historically has focused on the ecology of the Midwest and Great Lakes regions and includes "scientific literacy for all citizens" in its mission.

The Science Scene program also draws on the resources of the Chicago Housing Authority, which provides social services for 250,000 residents of public housing communities, and the Northwestern University Medical School, which offers modern scientific facilities and graduate students who are committed to working with teenagers. The multilayered mentoring program is supported by the HHMI grant.

A Wonderful Combination

Science Scene builds on an existing program that was designed to attract more teenagers to the museum, particularly those from underserved communities.

A partnership with the housing agency was born when the agency approached the academy and other cultural institutions to help meet residents' educational needs, with a particular emphasis on encouraging

Teens of the Science Scene: KIDS and TEENS program of the Chicago Academy of Sciences.

young people to complete high school.

Lynell Hemphill, director of education and cultural affairs for the agency, recalls saying during the first meeting between the agency and the museums, "You have the programs, we have the people—what a wonderful combination." She adds that the academy was the first museum to respond with a substantive program.

The core of Science Scene is a two-year program for teenagers from the Henry Horner Homes, a well-known public housing community of approximately 4,000 residents, 95 percent of whom receive some form of subsidy. The conditions of the Horner community have been documented in the book (and subsequent Oprah Winfrey movie) *There Are No Children Here.*

The Science Scene teens learn molecular and cellular biology from Ph.D. students at Northwestern University on alternate Saturdays during the academic year. On the other Saturdays and Sundays, they work and receive additional training at the museum.

Twice a month they conduct science workshops for elementary students. They also serve as counselors to the younger children for week-long camps during the summer.

Two premises have shaped every aspect of the program, including its structure, scheduling, and curriculum development. The first is that young students from educationally and economically disadvantaged backgrounds need more than just a "one-shot" encounter to interest them in science; they need some sustained, in-depth experiences. The second premise is that, based on the academy's experience, teenagers learn best when expected to teach.

Saturday's Children

In the 1993–1994 academic year, the Chicago Academy operated a pilot

version of Science Scene with 12 teens and 7 graduate student mentors, most of whom continued when the first full two-year program began in September.

To be eligible for the program, the teens needed a grade average of C. They were also chosen for their leadership qualities and their excitement about learning. In the first group, the seven young women and five young men ranged in age from 14 to 16 years, and their ethnic backgrounds were African American, Latin American, and Asian American.

Meeting with their mentors for a minimum of three hours every other Saturday, the teens were introduced to genes, proteins, cells, membranes, and other topics in biology. Basic scientific methodologies were illustrated. After a short discussion on the topic of the day, the teens used the university's advanced equipment to examine their subjects. In one session, they learned the complex process of staining cell proteins. Then, using an electron microscope, they were able to see the "skeleton" of cell proteins in detail.

The teens studied DNA with mentor Amy Trejo-Skalli, a third-year Ph.D. student doing research on tumor cell biology. Among other things, they learned to cut DNA with specific enzymes and to analyze the resulting fragments by gel electrophoresis. And it was a learning experience for the mentor as well.

In demonstrating the electron microscope, Trejo-Skalli's students, she said, were much more interested in the properties of the liquid nitrogen she used to prepare the microscope than in the high-tech equipment itself.

"They were apparently fascinated with the fact that something that was a liquid one instant could so easily convert to a gas and that it could still be so cold that it could damage your skin," she recalled. "It surprised me that they would be much more interested in discussing a common substance such as liquid nitrogen than the technologically sophisticated electron microscope."

This was echoed by mentor Rob Caldwell, a Ph.D. student studying virology. "Initially, they were amazed by what seemed to us mundane things. Later, when we were showing them complex molecular designs on a 3-D computer, they had stopped being dazzled by the machines and were focusing on the biology."

While all the teens received the same basic instruction during their first year, the mentors hope to be able to spend the second year exploring their personal research interests with the youngsters.

"We'd like to have them develop their own research projects so they can contribute to the lab research or enter a science fair," explained Cathy Fillmore, a mentor and Ph.D. student who had just finished her second year in the department of pharmacology. "I really want to know how they do [in the future] and to help them out," she added. She anticipates continuing as an informal mentor after the two-year program is over.

Antonio Torres, a 9th grader at Young High School, meets Northwestern University mentor Leonard Anderson as part of the Science Scene: KIDS and TEENS program.

Think Like a Biologist

On alternate Saturdays the teens go to the museum, where they learn to give tours and demonstrations and to explain various museum exhibits. The instruction provided by the museum includes basic biology and ecology, and reinforces what the teens learn at the medical school.

During the 1993–1994 pilot program, they gave chemistry demonstrations, played an energy conservation game, and did a "touch trunk" activity based on natural history specimens. As the program continues, they will be encouraged to pursue independent study—for example, to develop a new way of approaching tours, or a new science activity to be used in one of the museum's programs.

Museum officials were delighted to see how quickly the teenagers achieved the desired level of competence. This is due in part, they believe, to the university laboratory experience. "Within three weeks, they had exceeded our expectations and learned everything we thought it would take them three months to learn," said Janice Siska, manager of visitor services and volunteers, adding that those expectations were based on the academy's previous experience with adult staff.

The curriculum of Think Like a Biologist, a facet of Science Scene, is complementary to the instruction the teens receive at the medical school, with emphasis on giving the science a real-life context.

For example, knowing that the students studied viruses, the museum provided information about effects and transmission of herpes simplex in a session on Changing Lifestyles in Society that the teens presented to the elementary children.

Similarly, in developing the Food Chain session, teens would draw on scientific information from the mentors about cell function, use of nutrients, and chemical structures. They would learn about nutrition from the museum, addressing such questions as Where do we get our food? How and why do we prepare food? Why do we need different foods? Once they master the information, the teens help develop the curriculum for the elementary students.

They use a self-administered test to identify areas where they need stronger skills, such as writing, computers, or even in addressing life problems. Then they pursue improvements through individually tailored programs and workshops, where they can also get help in preparing for standardized scholastic aptitude tests and applying for college.

Walking in Their Shoes

According to Carol Fialkowski, project director and vice president for education and exhibits at the academy, the success of this and similar programs hinges on early and close consultation with the community, both to build trust and to make sure the program fits its intended beneficiaries.

"We wanted this to be a partnership, something that is mutual, rather than just going into the community and trying to impose a program," she said. "Sometimes we have a tendency to think we know what people want, what's good for them. But we're not walking in the same shoes. This has put us in touch with the needs of a whole community where the bridge building is very complex."

As the program was being developed, academy staff learned about the special barriers to participation created by neighborhood conditions. They found it necessary to avoid street gang territories and to start the program later in the morning to accommodate teens from single-parent households.

Community consultation is also maintained through the Science Scene advisory council. In addition to representatives from the museum, the housing agency, the Henry Horner community, and the university, the council draws from a number of other science and community organizations with similar goals. These include the National Science Foundation–funded Access 2000; CADRE (Combating Alcohol and Drugs through Rehabilitation and Education); Aspira, Inc., an organization devoted to leadership development through education, primarily in Latino communities; Science Linkages in the Community (SLIC), a program of the American Association for the Advancement of Science; Argonne National Laboratory; Amundsen High School, the city's environmental high school; and the Chicago Urban League.

As part of providing a sustained experience, "graduates" of the Science Scene are strongly encouraged to go into other science and technology-related programs, many of which are offered by the organiza-

tions participating in the advisory council.

Dana Pittman, the CADRE representative, believes that this aspect of the program will help it have the most long-lasting effects. "More than just going to the one program, this gets them plugged into a system that will track them through college."

Science Scene has a substantial assessment component designed by Jon Miller, noted authority on science education evaluation and vice president of the academy. The evaluation will measure the success of the program through individual assessments of the participants and comparisons with a control group and national databases.

In addition to background and attitudinal questionnaires and science and mathematical achievement tests, the teen participants will fill out evaluations on the programs. Skills will be assessed on the basis of the criteria recommended by the Secretary's Commission on Achieving Necessary Skills. Both the teens and younger students will be tracked after they leave the program.

The Future of the American Landscape

"It's not just the museum that has something to give," notes Hemphill. From her perspective, Science Scene and other programs that provide early interventions and jobs for teens "are needed more and more because these people are out there—but they also have a lot to give."

Fialkowski and others note emphatically that the benefits of the program are twofold: "Museums are not often the destination of minority populations, and many people don't have a cultural history of museum visitation and participation," she observed.

"So, as we work to diversify and open our doors more widely, programs of this sort are invaluable for putting us in touch with new constituencies that we might not ordinarily have been involved with." And, as Siska notes, "having the young people at the museum lets us see the future."

For Juri Jones, the academy's community program coordinator who works with the teens to develop the elementary level curricula, the most rewarding part of the program is "the opportunity to give the world these future scientists."

"I've got kids in the program now that I can see becoming teens in the program, and eventually becoming mentors, and eventually becoming scientists," said Jones. "Being able to work with them so young is what's going to make a difference," she said, "because they're seeing science as a fun thing to do."

Institutional Profile

Annual attendance	70,000
Annual budget	$4,000,000
Annual education budget	$700,000
Endowment	none

CHILDREN'S DISCOVERY MUSEUM OF SAN JOSE

A River Runs Through the Heart of a Science Education Program

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The Children's Discovery Museum of San Jose is a children's and youth museum in San Jose, California. In 1993 the Howard Hughes Medical Institute awarded it $175,000 to support BioSITE, a comprehensive environmental research program serving 1,400 low-income, primarily Hispanic children, families, and teachers in the downtown area. The museum's 11-acre site on the banks of the Guadalupe River affords an opportunity to study both large- and small-scale variables—manmade and naturally occurring—and their impact on a unique urban ecosystem. During the school year, 140 4th and 5th graders participate weekly in an in-depth field work experience. A series of four workshops for training teachers, facilitators, and parent-maestras precede the field program each semester. The program also provides a resource bank of supplies customized for field work and for check-out or use at school, other community sites, or at home, and a computerized database into which research findings can be logged as part of computer lab programs in place at the participating schools.

Surrounded by the high-rise buildings in downtown San Jose's tough Gardner neighborhood, the Guadalupe River is an unlikely location for budding scientists to be measuring salinity, pH, temperature, and velocity. Yet every Monday during the school year, about 140 children arrive at the museum for a two-hour session at the Guadalupe site. Binoculars in hand, they spot hummingbirds and hawks and try to match birdsongs with audiotapes.

Later, they can return to Doodad Dump, an area in the museum full of scrap materials donated by companies, to design better equipment or build a faster boat for the next week. Adjacent to the museum, the river is undergoing massive change as a result of a $100 million urban park/flood control project, whose impact the program participants will study over time.

"This program offers the kids science in the outside world—their world," says Roslyn Rubesin-Eigler, the HHMI program director. "The outdoor setting tends to encourage them to ask more significant questions, perhaps because of the informality of the structure and the absence of a single authority figure and because they are devising their own experiments. Besides, this is fun."

The children are teamed with facilitators at a ratio of 5 to 1, as well as two bilingual science resource liaisons. Together they spend the better part of the session in and around the river engaged in activities outlined in carefully designed lesson plans. Through BioSITE (Stu-

dents Investigating The Environment), Children's Discovery Museum is tapping the Guadalupe to serve as an outdoor laboratory for two inner-city schools in the San Jose Unified School District. The groups are mixed between the two schools in a deliberate effort to cross rival gang turfs.

The program is specifically designed to serve low-income, primarily Hispanic children, families, and teachers clustered in disadvantaged neighborhoods in the downtown Gardner district of the city. With the HHMI funding, the museum was able to obtain matching funds from Cisco Systems of Menlo Park.

Making a scale model of the Guadalupe River during a BIOSITE activity.

Planning the Program Required Community Effort

During the early phase of the program, museum staff collaborated with many individuals to identify and recruit participants, hire and train facilitators, procure supplies and equipment, design the program, and develop the curriculum.

The participants included Rubesin-Eigler, teachers from Gardner Academy and Washington Elementary Schools, and facilitators recruited from San Jose State University, Santa Clara University, and the museum's Volunteer and Discovery Guide programs. Every effort was made to recruit females and minorities as facilitators. The facilitators from the two universities are primarily students of environmental studies, biology, or education. BioSITE has afforded them a matchless opportunity to hone their skills and test their planned career commitments.

The program design and curricula were developed by Rubesin-Eigler over the fall months in collaboration with Les Roundtree and Frank Schiavo of San Jose State University's Departments of Biological Sciences and Environmental Science and Education, and with participating teachers and community organizations such as the Environmental Volunteers, Aquatic Habitat Institute, Youth Science Institute, Creekwatchers, Audubon Society, California Aquatic Science Education Consortium, and Santa Clara Valley Water District.

The focus of the research is the Guadalupe River and its riparian zone. Scientific subject matter

includes biology, geology, chemistry, meteorology, botany, and physics, which together enable study of the river's ecology.

To offer a target group of teachers and facilitators the opportunity to engage in authentic scientific processes, the new curriculum was crafted to expose children to important concepts in natural science. Strategies were devised to assist students in developing their own tools to observe phenomena and to provide the opportunity to use first-rate scientific instruments in addition to their own designs.

Students are encouraged to use "authentic" language to describe their experiences. The specific activities are designed for use in small groups to enhance observation and data collection skills in a simple, open-ended, joyful, nonthreatening manner. An overriding intent is that each student achieve a feeling of success at some level during each activity.

A Varied Program

The first eight lessons include orientation to the program, the river and its urban setting, and the scientific disciplines involved. The last seven focus on experimentation. Students engage in active experience and observation, exposure to tools and instruments, documentation and record keeping, and formulating and testing hypotheses. During each session, techniques are introduced for data collection and record keeping, and new instrumentation is introduced or built.

For example, the children built simple hand viewers from coffee cans and plastic wrap, watched eggs float in salt-saturated water, and measured the temperature of air, water, and soil. Boats were built, floated, and timed to determine the stream velocity.

They dissected owl pellets to illustrate food chains. Spotting scopes and binoculars were used to watch the growth of bird populations in the spring. They analyzed water life, learning about niches and scientific nomenclature in the process. The stronger the connection to real life, the more the children were fascinated. One 10-year-old boasted, "When we dissected a fish, I was the only one who did, and it was fun!"

Positive Results

The students were introduced to numerous scientific concepts and terms over the course of the program. It was also emphasized that they could devise and build their own tools to investigate areas of interest.

To the satisfaction of museum staff, the students have assimilated the BioSITE information and have begun to use scientific language in their daily conversations.

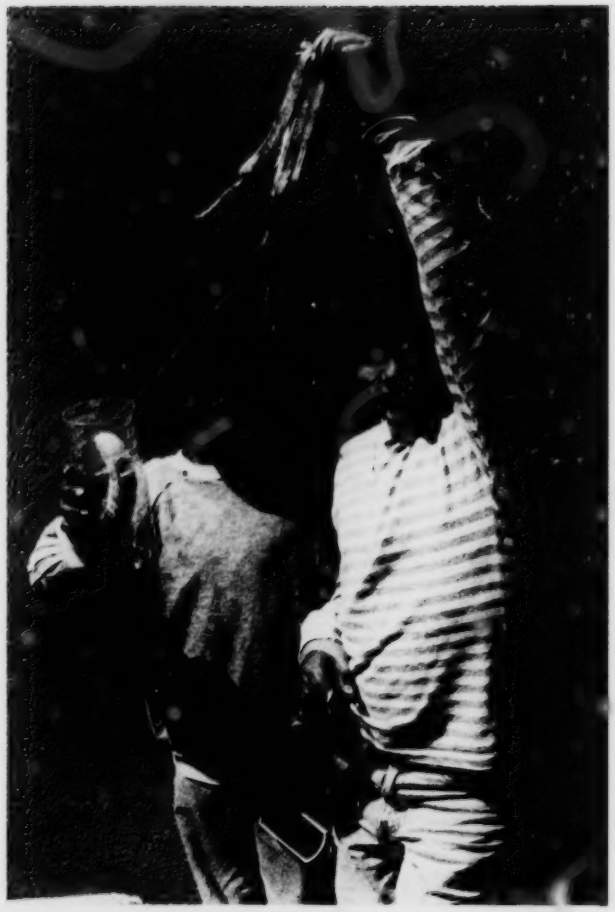
Although the program is still developing, a solid appraisal is now possible, both in terms of its impact on the children and on the museum. The children could not have such experience in the classroom. By link-

ing science to a river that runs through their neighborhood, the program connects participants concretely to the subject matter under investigation. The youngsters know this river, and they care about it.

Through interviews the participating teachers have learned that the children are beginning to realize how people influence their environment. They see nature as part of their world, revealing a new appreciation for the interdependent nature of the ecosystem. They no longer see science as separate from other subjects.

Further, the decision to work in small groups has proved beneficial. For example, facilitator Erin Mahoney was reading about insects with three 5th-grade girls. One was fluently bilingual (Spanish/English), one could speak both languages but could only read Spanish, and the third had recently arrived from Mexico and could only speak and read Spanish. The first girl was reading in English to the second girl, and the third girl was reading in Spanish to Mahoney.

Design of Experiments. Although systematic research procedures were introduced through various data collection processes, this goal was the hardest to achieve, according to Rubesin-Eigler. From the first year of the program, staff have learned better how to structure a sustained research project, have recognized the need to spark the children's interest at the outset, and have noted the importance of providing an outcome that the children will view as valuable.



Miguel's banana experiment.

For final projects this year, the children designed their own experiments, varied in style and objectives. They monitored decay through an ingenious experiment involving a jar, a banana, and an accessible ant colony; built a pond and monitored its ecology; built a scale model of the river site; studied pollution in the water; and took inventory of the stream's wildlife.

The banana experiment was created by Miguel Soto Jr., who insisted on using a banana, a clear container, nylon stockings, and a rubber band. "We smiled and complied without

question," reports Rubesin-Eigler. These materials were artfully combined to create a predictable fruit fly population experiment that, over the weekend, terminated in predictable ecological dissolution as ants moved in at the final stage of the banana's decay.

Better Relationships. The program also appears to be affecting the children's attitudes toward science. Recently a 5th-grade boy, who had seemed an unwilling participant during the first eight weeks of the program, stamped his foot during one session and exhorted his classmates, "Be quiet and pay attention . . . this is science!"

The program is affecting relationships among the children. The neighborhoods of the Gardner district have rival gang turf gerrymandered through them. The gangs have a powerful influence even on 4th- and 5th-grade children, and gang affiliations begin early in the children's lives.

Facilitator Karriem Stinson, a student at San Jose City College, knows the streets. According to Rubesin-Eigler, he is young and smart, and cares deeply about these children. Early in the program, he had to break up more than one fistfight and often served as a mediator. Now these youngsters not only respect and trust him, but have begun to respect and care about one another. The structure of the program forces them to work together as a team.

The initial BioSITE sessions revealed a host of challenges to be resolved, according to Rubesin-Eigler. They included simple issues: how long the children could focus, how many activities could be accomplished successfully, weaknesses in the curriculum, and the need for further integration of the school and the museum curricula. They also uncovered complexities not expected—gang violence, abuse of property, children's personal rage, and how to integrate a formal program into the museum's informal culture.

Despite these difficulties, Rubesin-Eigler is confident that the relationships formed were important to the children. The importance of these interactions is emphasized in a letter from two of the teachers, who noted, "Another really important aspect of the program has been the facilitator-student ratio. Many of these children do not experience much quality time. This has boosted their self esteem and put them in a high-quality learning situation."

The close rapport between students and facilitators has given an opportunity to adapt the lesson plans to speak directly and specifically to the children, thus overcoming early barriers in language, exposure to science, and interest.

Student Facilitators Benefit. The facilitators' experiences have also been encouraging. Two have entered into teaching credential programs, and two will begin teaching science either in homes or public schools next semester. One facilitator has accepted a teaching position with Head Start, and another has decided to study environmental law. Stinson, a student at San Jose City College, will continue his education to become a science teacher.

As one facilitator stated in a final report, "If I did my job right, which I know I did, the children I taught will come out with a better understanding of what it means to be a part of an ever-changing ecosystem, how to work together, and how to think for themselves. Whatever else these children may lack, education is something that will always be theirs."

The Difficulties of Family Involvement

Originally museum staff envisioned family participation through its volunteer parent-maestra program, geared to help parents help kids through involvement in school and museum activities.

Unfortunately, most of the children's parents, who live in a primarily low-income Hispanic neighborhood, could not take time away from their jobs during school hours. The maestra parents who might have participated were already committed to working at the schools in other capacities, such as yard and bus duties.

Recognizing this limitation, Rubesin-Eigler conceived a final celebration for children and their parents. Scheduled for an evening in June at the museum, this was a family event designed both to honor the children's accomplishment and to build parental pride and interest. Invitations were printed in both Spanish and English, and there was a full house.

The occasion also provided an ideal lead-in to museum use during the summer. To this end, all families were given full memberships entitling them to free, unlimited admission for one year, museum publications, and discounts in the museum store.

In the fall of 1994, the museum sought to include older siblings, cousins, and other family members by offering internships to local high school students. Rubesin-Eigler hopes that the success of this year's activity will prompt teachers to assist in recruiting extended family from their classrooms. She also plans to work with related community groups to identify community enthusiasts and role models.

Institutional Profile

Annual attendance	263,478
Annual budget	$3,358,371
Annual education budget	$990,465
Endowment	$1,650,594

CHILDREN'S MUSEUM

Science Made Personal for Inquiring Minds

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The Children's Museum is a children's and youth museum in Boston, Massachusetts. In 1993 the Howard Hughes Medical Institute awarded it $275,000 to support Inquire Within: A Personalized Approach to Environmental Exploration, in collaboration with the Boston public schools. Participants are 5th-grade students and teachers. Approximately 400 are involved in the five-year development, testing, revision, and dissemination of core materials and activities. The project includes (1) summer institutes and workshops to train teachers in biology and environmental science; (2) home-based family guides and prototype environmental monitoring kits for children; (3) school-based teachers guides and kits for monitoring reactions of the human body in the school yard environment; and (4) visits to the museum's floating urban environmental education center. Anatomy, biology, physiology, meteorology, and ecology are addressed through inquiry-based investigations. Both technological and child-made instruments are used to monitor responses to environmental stimuli.

Boston's waterways have been the site of revolutionary activities in the past, so it is fitting that the city's aquatic environment is a key feature of a program that will attempt to revolutionize science education for some of the city's public school students and teachers.

As the name suggests, Inquire Within: A Personalized Approach to Environmental Exploration centers on the individual student as the starting point for analyzing and understanding the scientific aspects of the surrounding world.

The program has been developed by the Children's Museum in collaboration with the Boston public schools, and is funded by the HHMI grant.

A Child-Centered Approach

Since the early 1900s, the Children's Museum and its predecessor institutions have stressed the use of artifacts and real-life materials in helping children learn about the natural and cultural worlds around them. Students in the Inquire Within program explore anatomy, biology, physiology, meteorology, and ecology by studying their own bodies as living organisms that interact with their immediate physical environment, particularly their school yards and homes.

In the latter years of the program, students will study the environment of the Fort Point Channel, where the museum is building its Urban Environment and Education Center, a

floating urban ecology exhibition informally known as the Barge.

The target audience for the program is 5th graders from city schools, where the population is predominantly non-Caucasian. This age group was selected in part on the basis of research indicating that students' attitudes about academic subjects are formed earlier in science than in other fields and that it is important to provide positive in-depth science experiences for 11- and 12-year-olds.

Further, in the Boston public schools, 5th grade is a time of transition from elementary to middle school, so it is the last time the students are in a "child-centered" environment. In the 6th grade, their education is more "subject-centered."

According to Diane Willow, science developer for the program, Inquire Within "is designed to involve children in environmental explorations that are concrete and developmentally appropriate rather than issue-based and abstract." Further, she indicates that the "child-centered approach emphasizes process skills that develop an inquiring mind and lead to a scientific approach to problem solving."

Inquiring Minds Want to Know

Museum staff collaborate with public school teachers to develop family and teacher guidebooks, environmental monitoring kits, guided tours, and similar educational aids. These are tested in small groups in pilot activities and refined for use in Inquire Within. Eventually the materials will be used throughout the public school system.

"This [program] is an integral part of our vision of science education over the next decade," said E. Ann Hamadeh, science coordinator for the Boston public school system, in a letter of endorsement that committed substantial school resources to the program.

The curriculum is consistent with the current science objectives for Boston public school 5th graders. It emphasizes science process skills such as observing, classifying, recording, measuring, and use of science tools, and outlines specific content within the categories of life science, human biology and health, physical science, earth science, and astronomy.

Curriculum topics include human body systems, body needs, animal behavior, life in the ocean, heat energy, and weather. The students investigate these topics first by finding out more about themselves and their own bodies, and then moving through progressively wider fields of analysis.

For example, they might begin by measuring changes in their body temperature at different times over the course of a day and under different conditions such as before and after drinking cold juice. This exercise then becomes the basis for a discussion about health.

Next the students might look at temperatures in their environment, perhaps by identifying warm or cold spots in their home, or determining

the wind-chill factor in their school yard, and these activities form the backdrop for discussing energy consumption. When they visit the Barge, which is scheduled to open in 1996, they will learn about contrasts of surface and bottom water temperature and talk about the impact of temperature on plant and animal growth or pollution.

Channel Changes

"The most important early business of the project is selecting the teachers who will take part in the four-year commitment," said Willow. "The program is designed to be a creative experience for people who want to take risks, discover new things. They are helping to plan the curriculum and will assist in preparing the Barge itself."

This core group of teachers will lead in developing the program's educational aids and be instrumental in designing a model for school group visits to the Barge, which will include pre- and postvisit materials and activities.

The current vision is that before visiting the Barge and the Fort Point Channel, the students will select a "focus area," or theme, to pursue in small groups in class and during field trips. The areas might include aquatic channel inhabitants, birds, water, the cityscape, or clouds.

Then they will visit the Barge and channel over three seasons, during which they will learn to collect data and how to make ongoing observations about the channel. These will involve daily monitoring of events such as tidal changes, water temperatures at varying depths, air temperature, water and air quality, and salinity and clarity of water.

Weekly channel inventories will include the variety and quantity of aquatic life forms; number, type, and behavior of observed birds; observations of plant life, terrestrial creatures, and human activity; and interviews with visitors, workers, and residents of the channel area.

The project has an advisory board composed of people from a broad range of professional and cultural backgrounds. In addition to Hamadeh, board members are Francie Chew, a biologist who runs an ecology laboratory at Tufts University, Billy Spitzer, an environmental scientist, Arthur Zajonc, a physicist from Amherst College, Marian Darlington-Hope, a Ph.D. candidate in urban studies who is a parent and educator with the museum, Nick Hadad, an educator and engineer, and Marquita Minot, an educator with the Boston public schools. By the end of the grant period, the museum anticipates being able to offer an in-depth program for 25–30 5th-grade classes annually.

Institutional Profile

Annual attendance	428,000
Annual budget	$5,792,035
Annual education budget	$2,758,721
Endowment	$4,183,733

DISCOVERY MUSEUM–LEARNING CENTER

Science as a Catalyst for Community Change

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The Discovery Museum–Learning Center (formerly the Sacramento Science Center) is a center of science and technology. In 1993 the Howard Hughes Medical Institute awarded it $225,000 to support the Community Partnership Science Project, targeted at K–9 students at risk for school dropout. The multiyear program includes introductory science experiences in community-based youth centers, followed by a summer science camp, volunteer experience, and paid employment at the museum. The project is targeted to youth in North Sacramento, an economically depressed area with a 65-percent minority population. A major emphasis of the project is the integration of biology with physical and earth sciences. The programs feature activities concerned with life and health science and with other science disciplines and curriculum areas.

Using strategies that draw from both parts of its name, the Discovery Museum–Learning Center has launched the community partnership science project to involve disadvantaged youth in science. The museum is using the HHMI grant to provide opportunities for students to discover and learn about science and, in turn, instruct others in their community.

The Layered Look

There are four parts to the community partnership science project: community science, a series of weekend events during which teenagers help bring science to elementary school students and their families; a summer camp; a volunteer program for selected camp "alumni"; and an "explainer" program in which volunteers train to become museum employees. Program director Elizabeth Etgen describes this as layering, which applies not only to the sequence of events, but also to the cumulative benefits that students will receive and the layers of support needed from community organizations.

During the first year of operation, the museum sought to carve out a niche in the community. It was able to make connections with existing community services to get started and, in developing activities, was able to draw on its extensive experience in providing science education, both in schools and at the museum.

But new strategies were needed to attract young people from low-income, educationally underserved neighborhoods, who are at risk for dropping out of high school and are not being reached through the usual avenues.

The program focuses on children and teenagers living in North Sacramento, one of the most economically depressed of Sacramento's eleven

Experiments ranging from physics to biology have been scaled to K–9 students in community partnership projects designed to introduce them to scientific concepts and methods. This student is working with an experimental electromagnetic cannon.

"community planning areas." The profile of North Sacramento is that of a community beset with the full range of urban problems affecting the educational status of its young people: 50 percent of students drop out within the first two years of high school; gangs and drug-related activity are major problems; 64 percent of students in at least one high school are on welfare; and another high school in the area has no library, has shut down its computer lab, and has eliminated funds for field trips.

There is a growing effort by neighborhood groups in North Sacramento to change their community, an effort that is being reinforced by the city's parks agency, social service agencies, a community college outreach center, and several churches.

The museum has tapped into this network of resources for planning and operating the community partnership science project, with the hope of contributing to the growing atmosphere of change in the area.

Reaching Settlement

One of the museum's chief partners in this outreach project is the Stanford Settlement, a community-based organization affiliated with the Catholic church. The settlement serves two predominantly Hispanic neighborhoods in the North Sacramento area. It assists families with everything from emergency food and clothing, to a senior center, to social programs for children and adolescents, and has collaborated with the museum on past projects.

"We have worked with the [museum] a number of times over the past 15 years and have been very pleased with their ability to interest our children and youth," said Patricia Pennisi, the agency's assistant director, in a letter endorsing the community science partnership project. "Unfortunately, due to lack of funding, we are not able to get to [the museum's] programs, and they, as well, are not able to get to us."

After consulting with the Stanford Settlement and others in the community, the museum learned that some students might be accessible through their community recreation centers. Consequently, several of those centers were selected as sites for the community science activities. The museum found an eager partner when it approached the city's Department of Parks and Communi-

ty, which provided the sites without charge.

Learning to Teach

The first three community science programs took place in the spring of 1994, after a fall and winter during which the curriculum was designed and young science "demonstrators" were recruited with the assistance of the Stanford Settlement and other community organizations.

Each program took place at multiple sites in the community over the course of a month. The demonstrators, who were junior and senior high school students, attended training sessions at the community center nearest their homes. In addition to learning the curriculum, they also received instruction in presentation skills, including how to explain scientific material to young children. Most of the demonstrators were girls, and all were of non-Caucasian backgrounds.

The core of each program is a series of five to six stations, or demonstration areas, at which the teen-aged instructors discuss various scientific topics and guide visitors through hands-on activities. The content of the stations changes in accordance with the theme for the month.

In March 1994, when the program theme was light and color, the demonstrators presented information on such things as the mechanics of vision, how polarized light is bent, magnification, and the effects achieved when color pigments or various colored lights are combined. April's theme was electricity and magnetism, and May's was the human body.

Happy Campers

The second component in the community science partnership project is a two-week summer camp at the American River College, a two-year institution that has donated classroom and laboratory space. Demonstrators are eligible to attend if they have participated in at least two community science events. All 19 demonstrators from the 1994 programs met the requirement. Eventually the camp will accommodate up to 30.

Louis Heinrich, a retired biology instructor and member of the museum's board of directors, is a guiding force behind the summer camp. In addition to arranging for the location and providing advice on scientific content of camp programs, he will also teach campers about biology and in particular the importance of understanding the relations among various biological systems.

Heinrich takes the approach that students learn best when encouraged to discover and think creatively about the subject they are studying. For example, beyond just presenting the basic information about the body's circulatory system, he would ask, "Why would this system have to develop? How would you have designed it?"

Each day, the campers will learn about a different topic, including chemistry; Native Americans; the human body (taught with cow heart

Hands-on science projects of the Discovery Museum–Learning Center are reaching children in an economically depressed area who are frequently lost to conventional channels of education. This student is learning properties of magnetic fields through use of magnetic marbles.

and eye dissection); earthquakes and geology; and endangered species and environmental awareness.

Campers will also have access to a creek that runs through the campus, where they will be able to run tests, identify various organisms in the water, and discuss such things as oxygen levels, turbidity, and pollution.

Campers will spend one day at the museum to visit the planetarium and learn about astronomy. On another day they will travel to the San Francisco Exploratorium to work in a kind of "buddy system" with students involved in similar activities.

In the fall, the campers will be encouraged to continue as senior volunteers with the community science project. Fortified by their experience of the previous spring and their budding knowledge of science, they will undertake increasingly responsible duties during the next academic year. After more advanced training, several will become paid explainers, assisting the museum staff.

A Science Little League

Despite the fact that much of the first-year effort was occupied with start-up activities, the community partnership science project had tremendous success in attracting and retaining the teen-aged volunteers. There was less success in getting members of the public to attend the community center events.

But far from being discouraged, the student volunteers remain eager, and museum staff, led by the program's community science coordinator, Peter Rowe, are enthusiastically investigating a host of ways to improve the low attendance at the monthly community science events, including more intensive publicity and possibly even appearances by local celebrities and sports figures.

The program will be assisted in this regard by an advisory committee which, in addition to Heinrich, includes the following community leaders: Robert R. Ball, author and speaker and a former director of the Governor's Task Force on Self Esteem, Joe Mims, a city parks and recreation superintendent, Connie Herman, a social worker and coordinator of the teen center at the Stanford Settlement, James Hicks, a teacher and North Sacramento resident, Rana Stevens, an employee of a health agency and North Sacramento resident, and Michelle Walker,

director of the Sacramento Arts Commission.

It is hoped that the science activities will eventually become standard community fare for younger residents. Mims sees a parallel with another community staple. "It's really no different than being involved in Little League," said Mims. "Many kids enter, but only a few go on to become athletes. It's the same with this science program—maybe only a few will go on in science, but at least they've had the experience."

Institutional Profile

Annual attendance	109,384
Annual budget	$960,588
Annual education budget	$180,260
Endowment	$18,527

EXPLORATORIUM

Working from a Solid Base of Success in the Physical Sciences

Program Director

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The Exploratorium is a general science museum and a natural history–natural science museum in San Francisco, California. In 1993 the Howard Hughes Medical Institute awarded the Exploratorium $175,000 to develop a life science teacher education program in the San Francisco Bay area. The curriculum focuses on perception and the senses; neurobiology and the brain; genetics, reproduction, and development; and human body systems—biochemical and immunological, skeletal and biomechanical, and cardiovascular and respiratory. The project will also develop a model exhibit-based teacher education curriculum with a strong interdisciplinary science foundation to support the needs of middle school science education nationwide. Through summer workshops, followup workshops, and special topic workshops, the project will develop a solid core of biology teachers for the middle schools. The Exploratorium's biology staff work annually with 200 other teachers in the existing middle and high school teacher institute program. By the end of the project, over 60 middle school biology teachers will have received intensive training, and 400 additional science teachers will have interacted with the staff.

From the Physical to the Life Sciences

The Exploratorium is using the HHMI grant to extend its teacher development effort into the life sciences. Although there are over 74 life sciences exhibits in its collection, this objective is not yet fully realized.

"Our life sciences section is very popular with the public," says Bronwyn Bevan, assistant director of the Center for Teaching and Learning at the Exploratorium. "There is a lot of regional interest because of our proximity to the biotechnology industry in the Bay Area," she adds. "Next spring we are opening a major exhibition on DNA, bioethics, and genetics."

Since 1985 the Exploratorium teacher institute has provided hands-on science institutes and workshops to Bay Area middle and high school teachers. The result has been the creation of an extensive network of educators in the physical sciences who use the museum as a resource for themselves and their students.

The HHMI grant allows the teacher institute to expand the teacher development program into the life sciences. Exploratorium staff have already been working on an informal basis with teachers interested in the life sciences in the past few years, particularly in areas of neuro-

©EXPLORATORIUM SAN FRANCISCO PHOTO BY AMY SCHNEIDER

In the Exploratorium's machine shop, teachers build biology exhibits for their classrooms.

biology and human perception. The life science education program formalizes the Exploratorium's commitment to develop and introduce teachers and students to inquiry-based science across the disciplines. The previous experience of the Exploratorium program in the physical sciences will also allow for connections to be made between the physical and life sciences in teacher training and curriculum.

Since its inception, the teacher institute has worked with thousands of regional middle and high school teachers. As a result, a cadre of over 700 teachers participate in ongoing advanced professional development activities in the physical sciences. The programs are all exhibit based, and teachers spend much of their time developing versions of Exploratorium exhibits, which they use in their classrooms as permanent teaching tools in inquiry-based science.

Teachers Are Reconnected with Science

Teachers in the life science education program come to the Exploratorium for an intensive four-week summer institute, which gives them a chance to rediscover their own fascination with science.

The program goal is to teach the teacher about science through exhibits and hands-on activities while modeling discovery-based teaching techniques for later use in the classroom. To allow teachers the opportunity to give four weeks of their time in the summer, they receive a stipend for participating.

"Summertime at the Exploratorium is an exciting, noisy, active, intense experience. Investigation and discovery are occurring all around us—on the museum floor, in the exhibit development workshop, and in the teacher classrooms. It is a

Teachers search for planaria, daphnia, and leeches during an Exploratorium Lagoon Safari.

©EXPLORATORIUM SAN FRANCISCO PHOTO BY AMY SCHNEIDER

very powerful learning environment that sweeps up both the teachers and staff," says Bevan. "This excitement carries over to the long-term professional development work that is offered in the subsequent academic year and beyond."

The life sciences curriculum focuses on subjects in human biology that are well represented in both the museum and the middle school curricula: perception and the senses, neurobiology and the brain, genetics, and systems of the human body.

"The teachers in our summer program are working with the phenomena on the museum floor every day, and go back in the classroom to discuss what they learned and recreate the phenomena there. We also conduct some of our own research, like dissecting a cow's eye for the perception section," says Bevan. "There is no one right way of gaining knowledge, so we use a variety of teaching methods. That's an important message for them to take back to their classrooms."

In the summer institute, teachers take their blood pressure readings and see how exercise affects the results. Part of the genetics component, this activity leads into a discussion of inheritance of risk factors for hypertension and heart disease. This activity is easily replicated in the classroom and teaches students how poor health habits interact with inheritance for diseases like hypertension.

After the summer institute, participating teachers have ongoing access to Exploratorium staff and resources. They become involved in a variety of related activities (e.g., follow-up weekend workshops, curriculum development efforts, and district leadership projects like workshops for colleagues).

Exposing other teachers to hands-on teaching methods will spread the sphere of influence of the

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Exploratorium program well beyond the participating teachers. Academic-year weekend and after-school workshops led by Exploratorium staff allow teachers to come together and share experiences and ideas and learn new approaches, building a regional cohort of inquiry-based, life sciences practitioners.

Improvement of the skills of middle school teachers will profoundly affect the students. Studies have documented that the middle school years are crucial to the student's level of science interest and understanding. Middle school science education is typically dominated by lecture format with little hands-on interactive learning, a phenomenon the Exploratorium intends to reverse.

Program Beginnings

Exploratorium staff have begun a search for the senior staff biologist who will oversee the program. They seek a candidate with extensive teaching experience and a breadth of knowledge in the life sciences. Because the position had not been filled, as an interim solution, the first summer institute in August 1994 was taught by Karen Kalumuck, a biologist from a local college.

Working with her was Tien Huynh-Dien, the Exploratorium's middle school biology teacher-in-residence from the Los Angeles Unified School District. The summer institute integrated physical and life sciences with study of phenomena explored in existing exhibits.

Staff planned the curriculum, recruited teachers, and acquired teaching resources for teacher and staff use. Resources to be obtained were recommended by both teachers and staff members. The materials included periodicals, curricular materials, online services, and audiovisual and multimedia resources.

Institutional Profile

Annual attendance	629,000
Annual budget	$11,900,000
Annual education budget	$1,640,000
Endowment	$4,033,000

HEALTH ADVENTURE

Reaching Out Across Time and Space

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The Health Adventure is a science-technology center in Asheville, North Carolina. In 1993 the Howard Hughes Medical Institute awarded the museum $100,000 to conduct a two-part Appalachian biomedical sciences initiative. Biomedical Sciences Discovery Saturdays rely on retired biomedical scientists from the North Carolina Center for Creative Retirement as teachers and facilitators of the weekly sessions. Participants in the project are disadvantaged and minority children in grades K–4 and their parents or grandparents. Families in remote areas are involved through Traveling Trunks, a community outreach program. The inquiry-based biomedical science activities stimulate interest in science and health through hands-on activities, observation, and experimentation in light and color, bones and movement, sound and hearing, the brain and creativity, and vision and visual perception. Participants are given Discovery Boxes to take home; the outreach program features specially designed suitcases containing biomedical science activities.

Set in the mountains of western North Carolina, the Health Adventure is a science and technology museum dedicated to health and related sciences education for all ages. One of its newer programs, the Appalachian Biomedical Science Initiative, is funded in part through the HHMI grant and involves an interesting experiment in intergenerational science learning. The museum has established direct working relationships with retired scientists affiliated with the Center for Creative Retirement at the University of North Carolina at Asheville. These retired practitioners share and enhance the joy of scientific discovery.

The Appalachian initiative aims to extend its programs through community outreach, often to remote sites, through traveling trunks and discovery boxes. These boxes will provide 4th–6th-grade children and their families the opportunity to participate in a museum program without leaving their community.

"There is an acute need for enhanced science education in rural Appalachia," says executive director Barry M. Buxton. "Poverty and isolation have a chilling effect on student aspirations in the sciences. Yet we have great hope because of the new partnership that is emerging."

The HHMI support comes at a time of challenge and change for the Health Adventure. Program attendance increased from 30,000 visitors in 1991–1992 to 70,000 in 1993–1994. Along with growth in the numbers of children and families that the museum reaches, there has also been an expansion in the number of rural

Hands-on science activities are an integral part of learning at the Health Adventure.

counties served. The Health Adventure now reaches all 25 counties in western North Carolina, and five South Carolina counties contribute almost eight percent of the total attendance.

A Key Partnership for Intergenerational Learning

The idea to recruit senior scientists for elementary science education programs was a natural for the museum. Maralee Gollberg, director of programs and exhibits, used to be at the Center for Creative Retirement and knows that community well. "We are blessed in Asheville with a wealth of people retired from science and medicine," says Gollberg. "These are absolutely vital people who have plenty of energy and a little more time to spend on the things they really love and care about."

The museum's goal was to involve recruits in a variety of activities most suited to their interests, talents, and styles. As of the summer of 1994 the Appalachian initiative had successfully recruited four members for its senior scientists team. They serve on a science advisory committee, help plan Discovery Saturday family science programs, and assist in the development of traveling trunks. In addition, each serves as a facilitator at a Medical Science Sleuth Summer Camp.

Tapping Into Regional Expertise

After the formation of the science advisory committee, it was determined that Traveling Trunks should be the first programmatic priority of the project. In November 1993 work began in earnest on creating the first traveling trunk. Each trunk must serve as a self-contained science outreach program, so the choice of topics was critical. Resource people who had successfully developed similar

Students learn about the science of magnets through hands-on experiments at the Health Adventure.

projects at the North Carolina Life and Science Museum in Durham and Discovery Place in Charlotte were consulted.

Along with trips to museums, the Health Adventure initiated contacts with the Mountain Science and Math Partnership. Director Joel Kelley stressed the importance of meeting specific school objectives as defined by the Department of Public Instruction in Raleigh.

Another key resource person in the developmental stage was Mary Schillereff, science specialist at Hall Fletcher Magnet Science Elementary School in Asheville. Museum staff observed science activities conducted in Schillereff's classroom, where she has not only used inquiry skills in presenting activities but has also taken advantage of volunteers from the community in implementing the program.

Dwight Hulse, of the Creative Retirement Center, a former superintendent of schools, provided valuable guidance on strategies for incorporating the trunks in area school districts. He also served as the primary liaison for recruiting retired scientists.

Have Trunk, Will Travel

It was decided that the first traveling trunk would emphasize inquiry-based science, using the inquiry process skills stressed in the new state science curriculum. After that trunk was developed and compiled, modifications were made in the activities and more explicit, concise directions were written so that the activities could stand on their own. Peggy Baldwin, a teacher at Rainbow Mountain Children's School, field-tested the first trunk, and modifications were made on the basis of her suggestions.

Development of the first trunk was a learning process that proved helpful as the Health Adventure staff began to create and test the second one. Prototypes of both traveling trunks have been fully developed and tested.

If It's Saturday, This Must Be Science

The Traveling Trunks initiative was envisioned as a program for reaching minority and disadvantaged children. Children and their parents who are within traveling distance will be attracted to Discovery Saturday programs at the museum. These two-hour morning programs are jointly devised and planned by staff and senior scientists and teach basic science concepts and encourage

future family scientific study and observation. At the end of each Saturday program, participating families take home a discovery box, which contains a science activity to be done in the home.

In 1994–1995 four Discovery Saturday programs will be offered. The topics were conceived by the science advisory committee, and each will be facilitated by a scientist from the Center for Creative Retirement. As in the development of the traveling trunks, cooperation between educators, museum staff, and the senior scientists was central. Together they developed guidelines and a training workshop to help the retired scientists adapt their knowledge and presentation style to the learning abilities of 3rd–5th-grade students.

Medical Science Sleuth Summer Camp

As a prelude to offering Saturday science discovery days, the Health Adventure staff developed Medical Science Sleuth Summer Camp, an intensive medical science experience for rising 5th and 6th graders. Three one-week-long experiences introduce participants to the research process, create an awareness of the role science plays in health careers, and involve families in further explorations of science and health careers.

Campers record their activities in a daily diagnosis diary and produce an audiovisual presentation for their families. On Fridays, campers accompany, or shadow, science health professionals to learn what they do. On Saturdays, families come to review the week's highlights, which include solving Curious Cases, science mysteries that are presented daily.

The wonder of science is discovered through a Wentzscope at the Health Adventure.

By the time campers have completed the course, they will have experienced the thrill of search and discovery, learned and practiced some principles of chemistry, biology, anatomy, and physiology, become aware of the role and training of health professionals, and experienced actual science and health settings. Through this combination of science and intrigue, campers will appreciate that an understanding of science can help them solve many problems.

Making It All Work

The part-time science coordinator funded through the HHMI grant has enabled the museum to enhance its programs and activities in the sciences. The Appalachian initiative has expanded its network of cooperating

organizations involved in science education.

Perhaps most gratifying to date, reports Buxton, is the new cooperative relationship between the Center for Creative Retirement and the Health Adventure. This relationship, which appears to be mutually beneficial, holds real long-term potential for improved education in the region.

Although it is still early in the life of the grant, it appears that both groups working together can effectively involve retired scientists in science center education efforts and do it in a manner that is intrinsically rewarding for the scientists. This type of work is not for every retired scientist, reminds Buxton, but there appear to be enough who welcome the challenge and want to play a direct role in improving the learning opportunities for disadvantaged youth.

Institutional Profile

Annual attendance	70,000
Annual budget	$470,000
Annual education budget	$329,000
Endowment	$300,000

IRVINE NATURAL SCIENCE CENTER

Nature Program Pairs Volunteers with Inner-City Children

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The Irvine Natural Science Center is a natural history museum in Stevenson, Maryland. In 1993 the Howard Hughes Medical Institute awarded the Science Center $125,000 to support Natural Connections, a program that trains volunteers to work with small groups of inner-city elementary school children in outdoor science activities focused on the characteristics and ecology of plants and animals. The activities are selected from the Outdoor Biology Instructional Strategies (OBIS) curriculum. With teenaged volunteers from high school science classes as leaders, sessions for 3rd graders are held twice each season in school yards and local neighborhoods. During the summer, eight weekly sessions for 8–10-year-olds are offered at recreation centers with the help of adults recruited from the local community. It is anticipated that 620 volunteers and 2,040 children from 20 pairs of schools and 10 recreation centers will have participated by the fifth year of the project.

When you're working with volunteers and children, you've got to be prepared for anything. Just ask Joe Harber, director of an HHMI-funded program that pairs volunteer nature guides with elementary students.

One recent summer morning, Harber left the lush green pastures of the Irvine Natural Science Center and drove 20 miles south, to Baltimore's Mount Royal Recreation Center. He expected to show a score of inner-city students how to make sun prints, using photosensitive paper and natural objects from the environment. Three recreation center staffers had volunteered to help.

But Harber's class included at least 25 boys, ages 7 to 9. One teacher was absent, leaving him with only two volunteers. Outside, clouds made it difficult to create sun prints quickly, and noise from a nearby road crew reached painful levels. "Well," Harber shouted cheerfully, "this is certainly a lesson about our environment." Undaunted, he relocated his group, which continued to grow as passing children stopped to take a look.

Despite the commotion, Harber's students were soon settled in a circle around him, watching intently as he made a sun print from grass, flowers, and a piece of litter—all from the school yard environment. Next the children formed teams to locate objects from specific environments described on notecards. Two nine-year-olds, Shakir Rashed and DeAndre Jones, peered through small magnifying lenses at objects found under a rock. Their sun print included grass roots, soil, and a stick. (They would have used an ant, too, but it kept crawling off the paper.) For DeAndre, the activity was fun with a purpose. "When we take the CTBS test, we do a lot of science," he said knowingly. "It's a long, hard test."

Joe Harber of the Irvine Natural Science Center shows inner-city Baltimore students how to make a sun print.

State-mandated assessment exercises like the CTBS (Comprehensive Test in Basic Skills) are placing greater demands on children like DeAndre, explained Lossie Mills, director of the Mount Royal Recreation Center. Fortunately, Harber's visits—scheduled as part of the Irvine Natural Science Center's Natural Connections program—are helping children improve their science skills, she added.

"When you see a chaotic situation out there," Mills said of the sun print activity, "that could mean the children are interested and absorbing and learning."

The Volunteer Connection

The Irvine Natural Science Center established its Natural Connections program in late 1993, after receiving the HHMI grant. Since then, the program has brought hands-on science to 644 elementary students, mostly African American, reports Robert Mardiney, Irvine's director of education.

Volunteers are a key to the program's success, he says. In the past year, 114 teen-aged volunteers were recruited and trained to lead elementary science activities during the school year. An additional 21 adult volunteers led training workshops for teens, worked directly with children, or helped maintain and restock 12 teaching kits.

Throughout the school year, pairs of teen volunteers offered six one-hour sessions for children at various inner-city "host sites." For each session, the teens received an activity kit based on the Outdoor Biology Instructional Strategies (OBIS) curriculum, developed by the Lawrence Hall of Science.

A Plant Hunt activity, for example, challenged children to collect, identify, and classify different types of plants. A lesson on Super Soil let children transform ordinary playground dirt into nutrient-rich planting soil. Yet

another lesson involved insect collection and identification. Different activities were planned for each host site, depending on the setting and the age of the children, Mardiney explains.

When teens work with younger students, he says, learning becomes a two-way street. "Our high-school volunteers may actually learn more than the elementary students. The older students are learning to be teachers and role models. At the same time, participation in the program can be a positive influence on their self-esteem."

Indeed, in response to a questionnaire about the program, one Northern High School student wrote, "It has helped me go for my dreams [of] being a doctor and succeeding in my goals." While high schoolers gain valuable teaching experience, younger students also benefit because they tend to view teens as role models. One elementary student wrote, for instance, "I will remember [my leaders] Shawn and Sean . . . and how much fun we had."

Since the State of Maryland requires high school students to complete 75 hours of community service, Joe Harber says, recruiting adolescent volunteers to work during the school year was easy. Locating adult volunteers to direct science activities in the summertime has been far more challenging, he adds.

Despite numerous news releases, flyers, and telephone calls, the Irvine Natural Science Center hasn't had much success in recruiting adult nature guides. Consequently, Harber and Mardiney are reevaluating their plans for an adult volunteer corps. In the meantime, staff members at host sites like the Mount Royal Recreation Center are lending a hand.

DeAndre Jones (left) and Shakir Rashed show an object they selected as part of an under-rock environment.

Reaching a New Audience

Just north of Baltimore in an affluent neighborhood known as Greenspring Valley, the Irvine Natural Science Center was founded 20 years ago. Olivia Irvine Dodge and her sister donated funds to start a 250-acre nature center on the campus of St. Timothy's private school for girls. As a graduate of the school, Mrs. Dodge wanted to provide educational opportunities for the surrounding community and preserve the natural beauty of the campus.

While the nature center provides an ideal setting for studies of organic gardening and life in a lily pond, the secluded location makes it inaccessi-

ble to inner-city students. From time to time, the center has experimented with minority outreach plans. But the Natural Connections program is its first full-scale effort to target a more diverse audience. "Until now, we didn't do much for the city schools," Mardiney says. "But we've wanted to do something for those children for a long time. We're finally getting our chance, through Natural Connections."

The program was made possible by the HHMI grant, funding from a half-dozen local foundations and support from a Washington, D.C.–based organization known as VINE (Volunteer-led Investigations of Neighborhood Ecology), part of the North American Association of Environmental Education. As members of the VINE network, Harber and Mardiney received expert advice from other educators who have established effective inner-city science programs in 11 other cities throughout the United States.

Even before the grant was awarded, a pilot version of the Natural Connections program served 230 students, thanks to VINE. "The previous work of other VINE members provided a blueprint for our program," Harber says. "We didn't have to waste any time figuring out the details or piecing together an appropriate curriculum."

The Natural Connections program has clearly been successful in reaching its targeted audience. Among the 644 elementary students served thus far, 91 percent were African American. At the Mount Royal Recreation Center, every child in Harber's sun print class was African American.

Most of the youngsters come from working families who can't afford trips to the seashore or weekend excursions to a country home, according to Recreation Center director Lossie Mills. Too often, she says, inner-city children never have a chance to learn about nature because their lives are spent primarily indoors, at school or home.

But are children really learning? To assess the educational benefit of OBIS activities, simple questionnaires are distributed to students, volunteer nature guides, host site directors, and teachers who take part in the program. Mardiney is also trying to figure out how to use MSPAP (Maryland State Performance Assessment Program) scores to evaluate children's progress.

For the most part, written comments about the program have been positive, Mardiney says. Teacher Beth Renwick of Sinclair Lane Elementary reported, for example, that her children were better prepared for the MSPAP exam because they learned how to use a magnifying lens as part of the Natural Connections program. Another teacher, Sandy Winkler of Yorkwood Elementary, described her students as "highly motivated and anxious for each new activity."

Institutional Profile

Annual attendance	15,000
Annual budget	$360,000
Annual education budget	$250,000
Endowment	$381,039

MILWAUKEE COUNTY ZOOLOGICAL GARDENS

In These Learning Zones, Children Won't Hit Any Speed Bumps

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The Milwaukee County Zoological Gardens is a zoo in Milwaukee, Wisconsin. In 1993 the Howard Hughes Medical Institute awarded it $200,000 to support the Educational Opportunities project, designed to stimulate interest in science and promote scientific literacy for urban minority students in grades 3–8. The project addresses age-appropriate learning objectives in zoology, morphology, botany, and ecology through the use of curriculum resource packets for classroom activities, six learning zones and materials at the zoo, a teacher training component, and a minority internship program. At the zoo students explore the scientific method with teachers and interns in living laboratories that include primates of the world, an aviary, apes of Africa, an aquarium, reptiles, felines, and Australian animals. The curriculum includes specific activities in language arts, mathematics, and social studies for pre- and postvisit classroom preparation and reinforcement. Training sessions assist teachers in integrating the resource packets and zoo experiences into the classroom curriculum.

Quick, what's a primate? When asked this question, 3rd graders in Milwaukee, Wisconsin, offered answers ranging from "a person who does crime" to "a young monkey or ape" and "something to do with math."

"I was shocked to find out that the children didn't know anything about primates," teacher Marion Henney says of a questionnaire distributed by the Zoological Society of Milwaukee County. "Then I started looking for instructional materials on primates, and I couldn't find anything at all for 3rd graders. That surprised me, too."

In fact, primates are an order of mammals characterized by extensive brain development, some use of tools, and complicated social systems, explains Mary Thiry, the Zoological Society's director of education and graphics. Primates include monkeys, apes, lemurs, bush babies, lorises, marmosets, tamarins, and man. Some primates have thumbs, while others, such as gibbons, don't need the extra appendage for moving hand-over-hand through tree limbs.

To help students in grades 3–8 understand the role of primates and other animals in the global ecosystem, the Zoological Society recently launched an Educational Opportunities, or Ed-Ops, project. Supported by the HHMI grant, the group plans to build special "learning zones" throughout the Milwaukee County Zoo. Marked by large Ed-Ops stations where teachers can collect lesson plans and other supplies, six learning zones will feature primates,

notably great apes; fish, reptiles, and amphibians; felines; Australian animals; and birds. The learning zones—combined with teacher training, instructional materials, and minority or female internships—are expected to stimulate children's interest in science and promote scientific literacy.

Female and minority role models, featured in instructional materials, are a key component of the Ed-Ops project, Thiry says. Unfortunately, she adds, an advisory task force working with the Zoological Society has so far been hard-pressed to identify regional role models. "Science in Wisconsin has, in the past, been pretty much oriented toward white males," Thiry notes. "The state is trying hard to get more women and minorities involved in research, but my group is having a hard time finding them."

Thiry's difficulty in locating appropriate role models underscores the need to encourage children's interest in science at an early age. Clearly, few urban minority youngsters discover research.

Among the 94,000 elementary and high school students in the Milwaukee public school system, 58 percent are African American, 10 percent Hispanic, 3 percent Asian, and 1 percent Native American. Yet, fewer than 10 percent of all science majors at the nearby University of Wisconsin–Madison are members of a minority group.

Biology, meanwhile, continues to stump most U.S. students. When the Department of Education recently gave a biology test to high school students in 14 countries, U.S. teens ranked last.

"Monkeys Say O-O-O-O-O"

In the fall of 1994, teachers who completed a training workshop were invited, along with their students, to tour a new learning zone focusing on primates. Thiry and her advisers worked on designs for the 3-by-5-foot Ed-Ops station, located outside a newly renovated facility housing 35 primates. (One design idea, for instance, called for a large walk-in box with a 3-D magnifying glass mounted on two sides.)

"The learning zone itself is more than just curriculum," Thiry says. "It includes hands-on activities and artifacts. Visitors to the zoo tend to look just at animals, and they're distanced from them. We're trying to immerse the children in an environment, to stimulate learning."

In developing activities for the primate Ed-Ops station, learning goals in the areas of zoology, morphology (the form and structure of organisms), botany, and ecology were carefully scrutinized to ensure conformance with state curriculum mandates. For example, one activity requires children to compare their jaws with fossilized primate jaws, which teaches them to identify food preferences based on tooth configuration. The activity introduces children to the study of morphology and satisfies a learning objective prescribed by the state.

The Ed-Ops task force also distributed a questionnaire to 6th and

3rd graders to assess children's knowledge of primates. Many individual responses were amusing. One 3rd grader suggested, for example, that apes and monkeys are different because they have "a different blood type." When asked to list what she knew about primates, another youngster pointed out that "monkeys say O-O-O-O-O."

Unfortunately, the cumulative results of the questionnaire weren't so amusing; in fact, they painted a grim picture of the students' lack of knowledge. "We found out that although we teach about primates in school, most kids don't know what they are," says Gloria Matoush, a curriculum specialist working with Thiry.

In response to the questionnaire results, the task force identified 13 basic questions that children should be able to answer, from What is a primate? to What are primate behavioral patterns?

Now that a curriculum has been developed for the primate Ed-Ops station, Thiry expects work on the five other learning zones to proceed more rapidly. "We spent a great deal of time on the planning process so that we could do it right," she explains. "We didn't want to introduce something and then have to retrofit it later. The activities we've developed will enhance the state's existing curriculum."

Adviser Gretchen Pearson, a veteran Milwaukee-area educator, hopes the HHMI-funded Ed-Ops project can be integrated with the zoo-based Urban Systemic Initiative, funded by the National Science Foundation. The zoo's program provides urban minority youngsters with better educational opportunities in mathematics, science, and technology.

A Living Laboratory

Through the Ed-Ops program, the Milwaukee County Zoo hopes to enhance its image as an urban learning oasis, a living laboratory in the heart of the city. Located on 198 acres of land, the 88-year-old zoo is completely surrounded by urban neighborhoods and receives 1.5 million visitors annually.

Over the years, the Zoological Society has established numerous zoo-based programs for local public school students, including a 1st-grade dairy program, a 3rd-grade science lab, and animal physiology courses. Roughly 200,000 students took part in the zoo's educational programs during the 1991–1992 school year.

By 1998 the Ed-Ops project is expected to reach more than 48,000 urban students. A diverse task force—including an African American, a Native American, two Hispanics, and two female European Americans—is customizing the language and images used in Ed-Ops materials to target minority students. Reaching minority children may be especially important in Milwaukee. At the Wisconsin Department of Natural Resources, the state's largest research-based employer, the percentage of minority and female

employees is extremely low, according to Thiry.

Kerry Scanlan, an intern hired to serve as a role model for children participating in the Ed-Ops program, hopes to change all that. "It's so easy to stereotype people," says Scanlan, a postgraduate master's student with a degree in geography. "Even some kids coming through school today think only men can be scientists. I can't wait to prove them wrong."

Institutional Profile

Annual attendance	1,400,000
Annual budget	$11,500,000
Annual education budget	$254,000
Endowment	$150,000

MISSOURI BOTANICAL GARDEN

Back-to-Nature Bio Activities Let Teachers Test New Skill

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The Missouri Botanical Garden is a botanical garden/arboretum in St. Louis, Missouri. In 1993 the Howard Hughes Medical Institute awarded it $125,000 to improve elementary science instruction in St. Louis. The first component of the program is a teacher training effort, in which 40 elementary teachers learn organismal and ecological biology, practicing new knowledge and skills with participants in a summer science camp and incorporating instructional improvements in their classrooms. In the second component, 240 inner-city children are trained in organismal and ecological biology. Concepts taught include organism, population, community, ecosystem, and structural components of the ecosystem and the biosphere; energy relationships, including photosynthesis, cycling of material, ecological interdependency and change, the relationship between complexity and stability, and carrying capacity. A hands-on investigative teaching approach is used throughout the program.

The scene was enough to give even the calmest teacher an Excedrin headache. A dozen blindfolded children, ranging in age from 7 to 9, were creeping through a grassy field, clicking toy frogs and shaking cans filled with pebbles. They were trying to locate their "mates"—other children making the same sounds—without getting tagged by a blindfolded "predator."

"We were studying how animals use sound and hearing to survive in a particular habitat," explains teacher Lou Birenbaum, who took part in a June 1994 workshop at the 79-acre Missouri Botanical Garden in St. Louis. "Because of the predator, children also learned that advertising isn't always a great survival strategy." During a similar activity, Birenbaum reports, smelly film canisters helped blindfolded youngsters find each other. Specimens of turkey feet and bird bills secured from the zoo, concealed in paper bags, gave the students a chance to use their sense of touch in identifying animal structures. Throughout such activities, Birenbaum and six other teachers were encouraged to "let it all hang out," by experimenting with new techniques in a supportive setting.

That's the whole point of the Botanical Garden's Natural Science Institute for Elementary Teachers, which is funded by the HHMI grant.

"The Institute provides elementary teachers with an opportunity to try many activities they might be afraid to try in their regular classrooms," explains Larry E. DeBuhr, director of education. "There aren't any principals wondering why children are making so much noise, and

Collecting specimens during a summer camp at the Missouri Botanical Garden. Children learn the structure of different organisms and how they interact with the environment.

teachers don't have to fill out mounds of paperwork every afternoon. They're free to develop new skills."

Over the five-year grant period, 12 outstanding K–6 teachers will be selected annually to complete a special training institute at the Botanical Garden. The same teachers will then be invited to practice new skills during summer ecology exploration camps focusing on organismal and ecological biology. With two camps planned every summer, each session should pair six teachers with roughly 36 students, DeBuhr says. By 1998 the program is expected to serve a total of 40 teachers and 240 inner-city students.

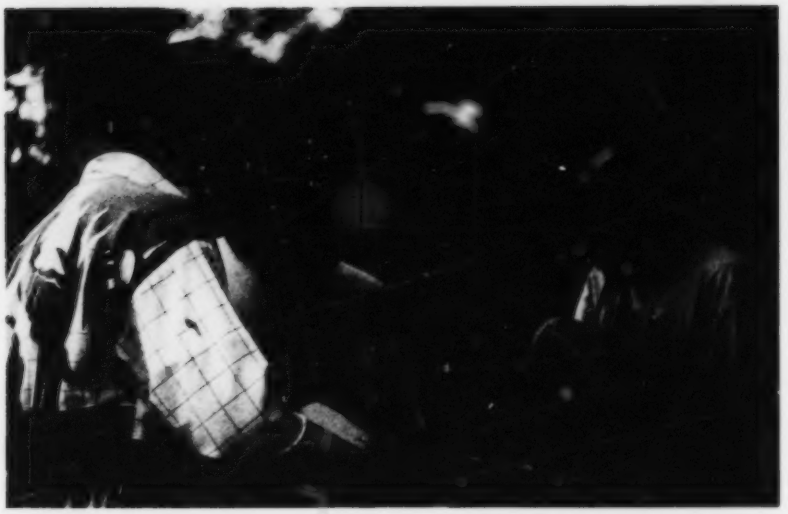
Nature—Up Close and Personal

Even when the temperature soared above 100 on the Missouri prairie, students attending a 1994 summer ecology exploration camp managed to have fun. They were herded onto the prairie for a "high/low" terrestrial measuring activity, explains Judith Ann Horton, a 3rd-grade teacher at Wedgwood School in Florissant, Missouri.

"We were studying the rain forest—comparing and contrasting the rain forest with the prairie and with a regular forest," Horton says. "Children measured the temperature where they thought it might be highest, and then where it might be lowest. We got a reading of 110 on the prairie, but it didn't seem to faze the children."

The high/low activity involves locating the most extreme examples of five environmental parameters, explains Judy Bramble, coordinator of teacher training at the Botanical Garden. For example, children might be asked to identify the wettest and driest spots, or very light and dark sections of a given habitat. "This activity opens kids' eyes to the fact that there is tremendous variation, even within a small part of a habitat," Bramble says.

Originally developed by the Lawrence Hall of Science as part of its Outdoor Biological Instructional Strategies (OBIS) program, the high/low game was customized for use by the Botanical Garden. Program directors also borrowed science



Learning to identify a variety of leaves common to the St. Louis area is part of a summer ecology exploration camp.

activities from the Missouri Department of Conservation, the Regional Environmental Education Program of Philadelphia, and other groups.

During another activity at the Botanical Garden's 33-acre Litzinger Road Ecology Center, children learned to identify a variety of leaves common to the St. Louis area, Horton says. A printing technique known as chromatography was used to adorn T-shirts with specific leaves. "They were getting pretty good at naming and understanding all kinds of plants," she adds. "We have stinging nettle here, and you'd better believe they learned to identify that up close and personal!"

Classification of plants and animals is a critical skill for elementary students, Bramble notes. "It sets the stage for investigation, because the first step toward scientific inquiry is looking and measuring and identifying patterns."

Elementary students need to learn organismal and ecological biology in order to master cellular studies at the high-school level, Bramble points out.

Through teacher training and summer camps, the Botanical Garden is focusing on the structure of different organisms and how they interact with their environments. Basic concepts such as adaptation, biological diversity, interrelationships, and ecological stability are stressed throughout the curriculum.

Better Science for Minority Students

Like Horton and Birenbaum, elementary teachers who practice new skills at the Botanical Garden may be better prepared to promote science in St. Louis classrooms, where 77 percent of the students are African American—a traditionally underserved population. To reach inner-city students, DeBuhr says, teachers need to get comfortable with inquiry-based techniques.

"Elementary teachers don't always feel comfortable teaching sci-

ence," DeBuhr says. "They tend to teach science not as an investigative, active process, but as a language and terminology process. In many cases, they don't have the resources to do it any other way. We believe this new program will help to correct some of these problems."

Unfortunately, DeBuhr says, recruiting students for an initial camp session proved to be more challenging than expected. The process began in March 1994, when participating teachers were asked to identify highly motivated students. Promotional flyers were also distributed to community groups such as 100 Black Men of St. Louis and the Herbert Hoover Boy's Club.

Even so, student turnout for the first camp session was disappointing, with only 26 children in attendance rather than 36. (The good news, however, is that 54 students are expected for the next camp session, thanks to stepped-up recruitment efforts, DeBuhr reports.)

"I think transportation might have been a problem for some of the children," says Lou Birenbaum, a teacher at the Willow Brook School in Creve Coeur, Missouri. A van or shuttle bus might help boost attendance at the next camp session, he adds.

Another problem for the Botanical Garden was to ensure that the new techniques would be transferred to the classroom. Teachers selected to participate in the HHMI program must agree to conduct workshops for their peers and use the new techniques. In exchange, they receive a $2,000 stipend, instructional materials, special training, and a chance to test activities with summer camp students.

Thus far, the program seems to be working: pre- and post-testing of teachers who completed a training session showed a significant increase in knowledge of science content, DeBuhr reports.

Rellus Clark, who teaches all-minority elementary classes at the Dunbar School in St. Louis, offers more anecdotal evidence of the program's success. "My students were learning about the rain forest inside the Climatron at the Botanical Garden," she says. "There's a box where you can drop a coin, and my students were so excited, they were saying, 'I have to bring money tomorrow. I want to help save the rain forest.'"

Institutional Profile

Annual attendance	900,000
Annual budget	$16,728,492
Annual educational budget	$944,166
Endowment	$34,528,000

NATIONAL AQUARIUM IN BALTIMORE

STARS in the Classroom: At the National Aquarium in Baltimore, Elementary Teachers Get a Helping Hand

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In 1993 the Howard Hughes Medical Institute awarded the National Aquarium in Baltimore $125,000 to provide support to the city's public school system in implementing STARS (Science: Thinking, Application, and Research Skills), a new science curriculum designed to meet the needs of urban children. The aquarium will provide elementary school teachers with workshops, field experiences, and kits containing support materials. Enrichment classes are provided for students in grades 2–5. Grade 2 teachers study vertebrate and invertebrate structure, classification, and adaptation for survival. Hands-on sessions with live animals and artifacts reinforce lectures and observation sessions in the aquarium. Grade 5 teachers study the natural and human history of the Chesapeake Bay through lectures, observations, and hands-on activities.

Using aluminum foil, the teachers carefully molded a miniature landscape inside a broiler pan. Now they added a drop of red food dye to represent the chemical waste from a factory—a form of "point-specific" pollution. It was all part of the HHMI-funded training program at the National Aquarium in Baltimore.

Throughout the process each teacher tried to imagine how her 5th-grade students might react to the exercise. "My kids would want to see the factory where this pollution is coming from," commented Nettie Spells of Coldstream Park Elementary No. 31. A small factory was created from paper and placed on a hillside.

"Point-specific pollution from industry is what we regulate now because we can figure out where it came from," explained Valerie Chase, an aquarium biologist. "A bigger problem is the non-point pollution." She scattered purple Kool-Aid powder across the landscape to symbolize fertilizer, pesticides, pollution from dumps and leaching landfills.

Next she instructed Patricia Gentry and Bettie LaBoo of Pimlico Elementary No. 223 to sprinkle some "rain" onto the landscape. Rapidly the red food dye and the purple Kool-Aid began flowing downstream into the same watershed, creating an untraceable mix. You could picture all the pollutants merging in streams and rivers and bays.

"The big push today is how do you deal with all the non-point source pollution affecting the Chesapeake Bay watershed," said Chase. "You have to educate people," said Doris Holt, a teacher at Baltimore's Dallas Nicholas No. 39. "That's right, we have to educate the next generation about these problems," Chase said. "That's why we're here today."

Teachers Nettie R. Spells (left) and Doris E. Holt create a watershed model to explain sources of pollution.

Beyond Rote Memorization

In inner-city Baltimore, elementary school teachers are struggling to implement a new science curriculum. Funded mainly by the National Science Foundation, the STARS curriculum builds on children's natural interest in the world, encouraging them to ask questions and develop problem-solving skills.

Because it was customized to reach urban youngsters, the curriculum may prompt more minority and low-income students to pursue a career in science, notes Sylvia James, the aquarium's director of education programs. It could also give these youngsters a boost in performing exercises mandated by the Maryland School Performance Assessment Program (MSPAP), she adds.

Unfortunately, many elementary school teachers aren't familiar with the science content of innovative educational programs. Others are uncomfortable with the "inquiry science" approach to learning, which emphasizes problem-solving rather than rote memorization.

That's why the National Aquarium established a training program for teachers, funded by the HHMI grant. Over the five-year grant period, the program will serve 240 teachers—at least one 2nd-grade teacher and one 5th-grade teacher from every public school in Baltimore. The 2nd- and 5th-grade units were identified because they focus on animals and the Chesapeake Bay, two areas where the aquarium's educational programs are already strong, James explains.

Each participating teacher will provide training to his or her peers at school, in exchange for in-service credits. Developed in cooperation with Baltimore's Office of Curriculum and Instruction, the aquarium's training program will complement STARS workshops provided at Towson University for elementary teachers of other grade levels. The program will be evaluated by William

Teachers Florence Jasmin (left) and Sharon Worwood measure water salinity using a hydrometer at a 1994 teachers workshop at the National Aquarium in Baltimore.

Boone of the University of Indiana, who plans to survey participants and attend part of a workshop.

"For many educators who had emphasized lectures and rote memorization in the past, this curriculum is a drastically new way of teaching, but it's effective," says James. "Along with the Baltimore public school system, we realized that if students are going to do well in a world that's increasingly dependent on technology, they're going to have to be able to pick problems apart and find the answers."

Understanding Our Environment

Stretching from the northern tip of Delaware to the Virginia state line, the Chesapeake Bay bisects Maryland's entire eastern region. Through fishing, recreation, and exporting from ports such as Baltimore's Inner Harbor, the Bay generates significant income for state residents.

But as biologist Valerie Chase sadly points out, the Bay has been damaged repeatedly by erosion, overharvesting of seafood, sewage, farm runoff, and toxic dumping.

A 5th-grade STARS unit reflects the importance of the Chesapeake, the nation's largest estuary, by focusing on its natural and human history. The unit covers water-quality parameters and habitats—from salt marshes to farms and factories—as well as bay animals and their role in the food chain.

Ecological problems, including nitrate loading of the water, are emphasized throughout the unit. Excess nitrate from fertilizers and cattle farming is a serious problem in the Chesapeake Bay and surrounding watersheds, Chase explained during a June 1994 teachers' workshop.

To demonstrate the severity of the problem, she asked teachers to measure nitrate levels in various regional water samples. At teacher Sharon Worwood's table, a sample of water from rural Baltimore County turned dark pink, indicating heavy contamination. Containing 9.5 parts per million nitrate, the sample was barely under the Environmental Protection Agency's limit of 10 ppm.

The STARS unit on the Chesapeake is challenging, particularly for teachers like Janet Gregor, who was not raised in Maryland. A teacher at Mildred Monroe Elementary No. 32, Gregor says she had to do a lot of research to familiarize herself with the Chesapeake Bay unit.

During the workshop, Gregor and 23 other 5th-grade teachers used a simple instrument called a hydrometer to test the salinity of different water samples. They demonstrated, for example, that water from a pond is less salty than water from a continental shelf offshore from the Bay.

Animals and Other Challenges

Early in the morning, when Baltimore's Inner Harbor is quiet and cool, employees at the National Aquarium are already explaining the difference between seals and sea lions. "Seals have no protruding ears," a staff member explains as a frisky seal named Marmalade pops her head above the surface of an outdoor pool.

With its marine mammal pavilion, extensive sting-ray exhibit, and shark-infested ImaginOcean, the National Aquarium is well situated to promote a better understanding of animals and their habitats. In developing a STARS training program, James and her colleagues decided to take advantage of the aquarium's strengths by focusing on the 5th-grade Chesapeake Bay unit and a 2nd-grade course titled Animals, Animals.

The 2nd-grade course will be taught jointly by the aquarium and the Baltimore Zoo. Program development was a challenge, James says, because school officials changed the animals unit at the last minute to emphasize life cycles, rather than large vertebrates. Nevertheless, the aquarium managed to retool its program before two dozen 2nd-grade teachers arrived for a workshop held June 27 through July 1.

Such training is essential to help teachers reach inner-city youngsters, James notes. In Baltimore 89 percent of the students in the public school system are African American, a group traditionally underserved by science education programs. "Minorities make up 10 percent of the population in this country, yet only 3 percent of the scientific community," James says. "That's got to change."

According to teachers like Nettie Spells of Coldstream Park Elementary, the inquiry approach to science education is an effective way to reach minority students. "The children I've been working with are so enthusiastic," Spells reports. "They're always asking, 'Can we have science today?'"

Institutional Profile

Annual attendance	1,500,000
Annual budget	$16,675,000
Annual education budget	$464,500
Endowment	none

NATIONAL ZOOLOGICAL PARK

Zoo Scientists on the Move

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The National Zoological Park is a zoo in Washington, D.C. In 1993 the Howard Hughes Medical Institute awarded it $125,000 to conduct a multilevel science education program that targets minority populations in five Washington, D.C., area schools. The program focuses on 4th, 5th, and 6th grades, involving a total of 3,600 students. The activities include (1) Scientist in the Schools, an interactive lecture series, (2) workshops to develop multisensory activities for students as a complement to on-site visits, (3) class visits to zoo laboratories and participation with scientists in theme-related activities, (4) development of computer-assisted learning on zoo-based conservation biology, with equipment and software placed in selected schools, and (5) teacher-selected student participation in five-week summer enrichment programs at the zoo.

"We are fortunate to have a cadre of young scientists here, people who want to motivate the next generation to be as excited about science as they are," says the National Zoo associate director for interpretive programs, David Jenkins. "The HHMI grant is encouraging us to be entrepreneurial in our use of these scientists."

The National Zoo, a unit of the Smithsonian Institution, has formed a partnership with four local elementary schools—three in the District of Columbia and one in northern Virginia.

The National Air and Space Museum (another Smithsonian unit) had developed relationships with these schools. Building upon these relationships, the zoo scientists are bringing natural science and the excitement of conservation into the classroom.

The involved schools have differing demographics, representing a cross-section of America's racial and ethnic diversity. The zoo is taking advantage of the diversity of its staff to provide the students of its partner elementary schools with appropriate role models.

Scientists in the Classroom includes zoo scientists of African, Latino, and Asian heritage. This is particularly effective, for example, when programs at Ross Elementary School, predominantly Latino, are presented in Spanish.

The Outreach Experience

Typical of the participating zoo scientists is Carlos Ruiz-Miranda. A Ph.D. in animal behavior specializing in vocal communications, he takes his program A Day in the Life of a Panther to the schools.

This particular program grew out of an initial interest in wetlands that was expressed by 11 teachers at the partner elementary schools. In

NOAHS Center
New Opportunities in Animal Health Sciences

putting together the wetlands program, Ruiz-Miranda emphasized the Florida panther, an American big cat population that the zoo is studying intensively.

Ruiz-Miranda wanted to use the life history of an endangered large mammal to emphasize the connectedness of the wetlands environment and also to extend the idea of ecological interrelationships to all environments, including the urban one. So, A Day in the Life of a Panther rapidly evolved into a continentwide exploration of animals and their environments via participatory storytelling. He sets the initial framework, and the children weave in their own concerns and experiences. This allows the experience to be personalized and more meaningful to the students than a formal, standup lecture.

Ruiz-Miranda points out that he presents the essential content with a style and context that is useful and engaging for the students.

Role-playing and games have proved to be useful tools for involving all the students in each class in the subject matter of each visit. For example, a "Panther Wheel" game helps to point out all the environmental and ecological issues that the Florida panther must overcome in its daily life. By spinning the wheel, students individually identify those problems and learn the panthers' strategies for success.

The zoo also uses the teachers' old favorite food web game. When strings that connect kids representing various elements of an environment are pulled tight, the group realizes that an event affecting one of them has cascading impacts for all.

Another point important in these discussions of the environment is the critical difference between "use" and "exploitation" of natural resources. Ruiz-Miranda differentiates between the two in order to develop the ideas of sustainable development and management of ecosystems.

Here the life experiences of many of the Latino students become a useful pedagogical tool. Things they learned in rural environments before coming to the United States are recalled and offer many examples of how the tropical ecosystems are being exploited and destroyed.

Ruiz-Miranda also points out that it is hard to work with elementary students. "I was more nervous going into my first Scientist in the Classroom session than I was giving a scientific paper at an international conference," he recalls. "I can't use my notes twice, and I sure have to think on my feet." Furthermore, the zoo has gained an appreciation of the variations among schools and teachers, and realizes the importance of responding to them.

That reaction is echoed by Bert Davis, a veterinarian who works on assisted reproduction in endangered cats. "The kids are really sophisticated. They read and they watch nature shows on TV. Every class has a cou-

Family Night at the Zoo: Elementary school students talk with an animal keeper at the Small Mammal House.

ple of exceptionally bright kids who constantly push me."

Like Ruiz-Miranda, Davis has had the experience of having a Latino immigrant pick up on his comments and describe first-hand experiences with tropical animals and environments when he was younger. Such peer-teaching enriches the experience for everyone, including the visiting scientist.

A Special Migrant

Migratory birds have proved to be a good way to relate the Washington, D.C., area ecologically to other parts of the world. The scientists ask the youngsters to think about the birds they see in Washington only at certain times of the year, and then to speculate about where those same birds are the rest of the time.

It turns out that the District of Columbia's "state bird," the wood thrush, is a migrant, wintering in Central America. This particular threatened bird has become very important to the students, who are now on the lookout for it.

Evaluation Efforts

Early evaluation efforts have been highly subjective, but informative. The most intensive effort was made by ecologist Mary Hagedorn, who used the visit of Panamanian ecologist Jorge Ventocilla as a means of exploring changes in the students' perceptions of rainforest ecology. She used the well-known technique of asking students to draw pictures of the rainforest before and after Ventocilla's classroom program. The drawings that were collected were thoroughly analyzed. It was determined that some measurable changes were apparent, even though the study was not rigorously controlled.

Initial (preprogram) drawings showed a higher number of generic animals and plants, with many ani-

mals represented as stereotypes and lacking specific detail. After the session with Ventocilla and zoo scientists, more particular animal species could be recognized in the drawings, their association with plants was logical, and representation of human activities showed people living and working as a part of the ecosystem.

Of particular note was the students' increased awareness of understory plants, suggesting a better grasp of the complex organization of rainforest environments.

Internal Impact on the Zoo

Both Jenkins and Ruth Stolk, the zoo's New Opportunities in Animal Health Science (NOAHS) director and project director for the zoo's HHMI program, believe that the project has had a highly desirable effect on the zoo staff.

As the program has developed, the zoo has had to market it internally. A significant concern is that this kind of public contact and educational activity is frequently not regarded as important by research scientists and is often poorly regarded by the existing reward structure. Efforts are under way to expand the reward system to include time and energy devoted to Scientists in the Classroom and similar activities.

While working to establish the validity of the program, the zoo staff realize that not all, or perhaps not even most, of its scientists should be a direct part of the Scientists in the Classroom program. But those who don't actually make the presentations and work with the kids are able to contribute specimens and slides. These help the growing resource center in training teachers to understand what kinds of science are done at the zoo.

Similarly, the zoo has worked hard to prepare the classroom scientists for the experience they will have and for the kids they will be meeting. It is likely that over the course of the program, more of the zoo's scientists will want to try their hand in an elementary classroom. The zoo fully expects that a number of them will be very capable of providing educational services at that level.

Institutional Profile

Annual attendance	3,000,000
Annual budget	$17,897,000
Annual education budget	$606,800
Endowment	$235,600

NEW YORK BOTANICAL GARDEN

New Botanical Program Offers Safe Adventures for City Children and Families

Program Director

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The New York Botanical Garden is located in the Bronx, New York. In 1993 the Howard Hughes Medical Institute awarded it $175,000 in partial support of the Children's Adventure Project, to offer children immediate experiences with plants and nature in a safe, discovery-oriented environment. The project has two components: (1) the adventure garden, where visitors interact with living plant collections integrated with explanatory exhibits, and (2) adventure trails, a series of activity-based walks through 250 acres of natural ecosystems. The project targets urban children in grades K–6, with emphasis on the immediate community. Using activity-based and inquiry techniques, children interact directly with living plant collections in a variety of settings and learn about the work of plant scientists. The project includes appropriate play activities to engage children who prefer different styles of learning.

At the New York Botanical Garden (NYBG), volunteer Edwin Martinez is getting in touch with his roots, literally. Every Saturday, Martinez tends a 20-by-20-foot Caribbean garden while chatting with NYBG visitors who stop to check out his handiwork. Growing up in the Bronx as part of an extended Puerto Rican family, "there was always some kind of cooking going on," he recalls. "A lot of stuff was happening in the kitchen."

Now, Martinez grows some of the foods he remembers from his childhood, including bananas, sugar cane, and a host of herbs, flowers, and vegetables indigenous to Puerto Rico and the Caribbean.

The Caribbean garden is one of four ethnic botanical displays maintained by volunteers in NYBG's family garden. Such family-oriented activities are part of a new children's adventure project being developed by NYBG in collaboration with school districts 9 and 10 in the South Bronx.

Through funding from the HHMI grant, the National Science Foundation, and other private and public donors, urban children in grades K–6 are learning first-hand how to plant a garden, maintain a compost pile, and study the life cycle of plants in a safe, supportive environment.

The project is also targeting parents and other family members, through an expanded menu of weekend and after-school activities. Designed to reinforce the message that "plants are alive," the Children's Adventure Project will bolster NYBG's educational mission to teach children and their families about the uses, appreciation, and significance of plants, reports project manager Catherine Eberbach.

The Children's Adventure Project has four key components:

SARAH CEDAR MILLER

Explainers at the New York Botanical Garden's Family Adventures project guide children's and parents' participation with sowing seeds, composting, and reading nature-related books.

- An adventure garden, where visitors can interact with living plant collections
- A family garden, based on an existing site reserved for hands-on gardening activities for children and families
- Ecology adventure trails looping through a mile of natural ecosystems
- A teacher partnership program for elementary science educators.

During the 1993–1994 school year, Eberbach and her colleagues began evaluating NYBG's many existing programs to determine which activities should be integrated into the five-year Children's Adventure Project. "We're taking our existing programs and making them interactive and hands-on," explains Paula Kascel, NYBG's director of campaign special projects. Project curriculum will also be guided by focus groups organized this year to survey Bronx-area children, teachers, and parents.

Hands-On Learning Fun

Plans for an adventure garden call for a new 1½-acre site, including both indoor and outdoor facilities, Eberbach says. After the garden is completed in the fall of 1996, children will be able to observe living plant collections and exhibits in four outdoor galleries and a plant discovery center, complete with a greenhouse and a children's herbarium and laboratory.

Each outdoor gallery will reflect a different scientific theme. For example, a wonder garden emphasizing biodiversity should treat children to "a spectacular, sensory overload of different shapes, colors, textures, and smells," Eberbach explains. Pollination, photosynthesis, and the interaction between plants and animals in a pond ecosystem will set the stage for three other outdoor galleries.

Learning goals for the adventure garden were identified after local ele-

mentary students, teachers, and parents participated in focus groups at the Botanical Garden, reports Rosemarie Garipoli, NYBG's vice president for development.

"I was shocked," Garipoli says of the survey results. "We found out that children don't know that plants are alive!" Through hands-on activities, visitors to the adventure garden should learn that plants are indeed alive—with specific life requirements, life processes, and an ever-changing nature, Eberbach says. "We also learned that parents and teachers want more access to science programs. They want to be involved."

Family Gardens. A second component of the Children's Adventure Project, a family garden, is being developed from an existing two-acre display. Children in grades K–6 routinely visit this garden during the school week as an integral part of their science curriculum. Unfortunately, Eberbach says, family garden programs have traditionally required a registration fee. To provide families with greater access to the garden, she says, "We've expanded our public programming so that anyone can drop in and participate in gardening and other activities on the weekends. In the future, these programs will also be available after school."

The Botanical Garden currently offers a multitude of family-oriented activities, such as a Greenthumbs program that allows visitors of all ages to grow flowers, fruits, and vegetables. Activities coincide with growing seasons. In August children focus on harvesting growing plants; in October participants learn to prepare a garden for winter.

CATHERINE EBERBACH

Discovery Carts, located throughout the garden, display touchable objects that give visitors a close-up look at plant and animal life.

Parents can get in on the action too, through initiatives ranging from science workshops offering take-home materials to roving discovery carts. In ethnic gardens, volunteers like Edwin Martinez serve as "garden diplomats," always ready to answer questions about plants.

"There are so many languages in the family garden, it sounds like the Tower of Babel out there on weekends," Eberbach says with a laugh.

"One Chinese family has become especially devoted to the garden. The mother is 72 years old, and she postponed a trip back to China because she didn't want to leave her plants during the growing season."

Adventure Trails. A third aspect of the Children's Adventure Project, new ecology adventure trails, will lead visitors from the adventure garden, past a wetlands, and through a 40-acre forest, Garipoli says. On the wetlands trail, children will learn how plants adapt to different water conditions. A forest adventure trail is also planned. Along the way, interactive learning stations and trained volunteers will provide additional information.

The teacher partnership, a collaborative support program for elementary science teachers, is now in the planning stages. NYBG staffers are still ironing out details, Eberbach says. But the garden planned to hire a master teacher, or manager of teacher enhancement, in the fall of 1994.

In general, Garipoli says, the teacher partnership will serve as "a kind of membership program, allowing metro-area teachers to gain access to the garden and to a teacher resource room planned as part of the adventure garden."

Community Outreach

Currently the New York Botanical Garden serves approximately 500,000 visitors, including 40,000 school children, each year.

"That sounds like a lot, but it's not," Garipoli notes. By 1998, she adds, NYBG hopes to serve an additional 400,000 visitors annually through the Children's Adventure Project.

To reach a much larger audience, the garden has begun to advertise its programs more aggressively. "We can't be passive and just send out flyers," Garipoli comments. "We have to really hustle for new business." Meanwhile, by using trained volunteers instead of paid docents, NYBG can offer a broader range of free activities for the public.

Eberbach is also investigating techniques for prompting rapid inquiry-based learning among visitors. For example, she says, exhibit labels that pose a question may stimulate learning more effectively than a conventional list of facts.

Opportunities for experiencing hands-on gardening may be especially critical for children in the neighborhoods surrounding the Botanical Garden. According to Glenn Phillips, NYBG's school programs manager, as many as 80 to 90 percent of all neighborhood children are members of minority groups. Of that population, roughly 70 percent are at or below the poverty level.

"Some of these kids have never picked up a worm before, have never planted seeds," he says. "We want to provide them with a safe environment where they can have those experiences."

Institutional Profile

Annual attendance	497,715
Annual budget	$22,105,341
Annual education budget	$1,782,645
Endowment	$24,077,880

NEW YORK HALL OF SCIENCE

Teacher Training Offers Peek at Hidden Kingdoms of Microbiology

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The New York Hall of Science is a science-technology center in Corona, New York. In 1993 the Howard Hughes Medical Institute awarded it $400,000 to train 350 7th-grade life science teachers in microbiology and provide materials, equipment, and an ongoing teacher support system. By enhancing instruction in microbiology, recently added to the state's 7th-grade science curriculum, the New York Hall of Science plans to build a critical mass of life science teachers for systemic reform of 7th-grade life science instruction in the New York City schools. For the duration of the project, 350 teachers will be trained. Each will teach about 100 students per year, making a total of 85,000 students who will benefit during the grant period alone. Topics of teacher training will include magnification and microscopes, collection and maintenance of microorganisms, fungi as an approach to teaching the microbial world, microbes as pathogens, and the immune system response. Hidden Kingdoms: The World of Microbes, a Hall of Science exhibit, will serve as a resource for project activities.

Twelve-year-old Valentina Pena was living in a homeless shelter when her science project took second place in a major New York City competition.

Valentina and her best friend Ruobing Wang had always been fascinated by ethnic folklore claiming medicinal properties for various herbs. To test such claims, the students compared the bacteria-fighting properties of garlic, ginger, and scallions with an antibiotic ointment. In a science fair for 7th graders from all Manhattan borough schools, the herb-testing system impressed the judges.

"Garlic proved to be an amazing antibacterial agent in their test, whereas ginger actually stimulated the growth of bacteria," reports teacher Susan Herzog of Intermediate School 223 in Manhattan.

"The project was quite challenging, and at one point Valentina was commuting two hours a day from the shelter. At the end of the year, she thanked me 'for making her brain work so hard.' It was very rewarding."

Valentina and Ruobing were inspired to study microbiology after Herzog attended the MICROLAB Institute, a teacher-training program at the New York Hall of Science. The program was established in 1992, thanks to startup funding from the National Science Foundation.

The HHMI grant provided additional support, while the New York City Board of Education paid for laboratory equipment. More than 80 teachers have attended the MICRO-

MICROLAB student using a high quality field microscope.

LAB Institute thus far. The goal of the five-year program, Hall of Science biology manager Martin M. Weiss reports, is to teach microbiology and laboratory procedures to 350 junior high-school science teachers.

Along with Valentina and Ruobing, an estimated 85,000 7th-grade students are expected to benefit from the program.

A Supportive Setting

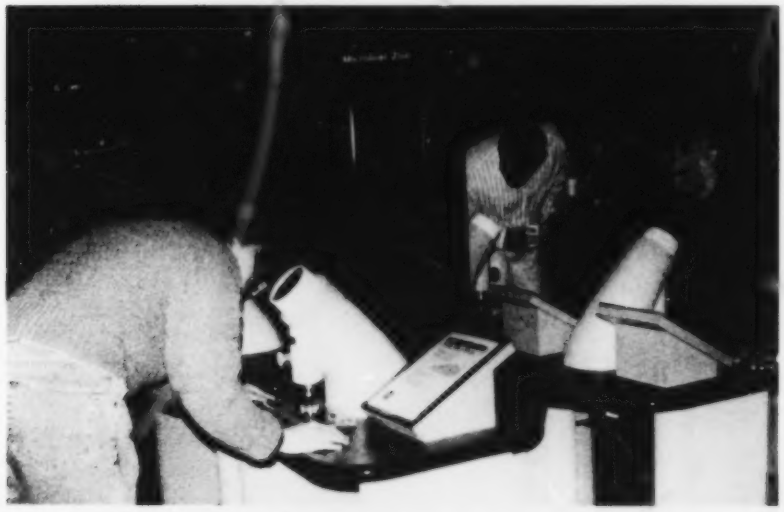
During a field trip scheduled as part of the MICROLAB Institute, one teacher tripped and fell into a lake. On another occasion, balloons used in a yeast metabolism experiment popped off vials and began flying around the classroom honking. If these mishaps had occurred in front of students, teachers might have been embarrassed. But the MICROLAB Institute offers a supportive setting where teachers can improve their skills without risking credibility.

"The great thing about our program is that it allows teachers to make mistakes so that when they do the activity with their students, they'll be confident and well prepared," explains John Hammer, education manager for the Hall of Science, located in Corona, New York. "In our program, they all make mistakes, and everyone has a good laugh and they learn from the experience."

MICROLAB participants like Carol Hochfelder, a teacher at the CJHS 145 School in the Bronx, New York, attend a five-day workshop, where they're introduced to the study of microorganisms—the bacteria, viruses, protozoans, algae, and fungi found all around us.

The exhibit Hidden Kingdoms—The World of Microbes serves as a springboard for teacher training activities. Through experimentation and discussion, teachers learn about the physiology, biochemistry, genetics, and function of microorganisms. They also collect and maintain specimens while working with laboratory equipment, including microscopes and video cameras, which can be borrowed later for classroom use. Post-training questionnaires help Weiss track each teacher's progress.

"The workshop was very nonthreatening," reports Hochfelder. "I didn't know how to look through a microscope or set it up, but the Hall of Science staff members were very patient. I learned to use the equipment, and I went back to my school and trained other teachers."



Participants tour Hidden Kingdoms–The World of Microbes at the New York Hall of Science.

More Than Just Germs

The study of microbes may be particularly critical for students in New York City, where AIDS and tuberculosis are continuing to spread at an alarming rate. Vaccine development and disease prevention in the future will require a better understanding of microbial functions. For this reason, a 1990 Institute of Medicine report, commissioned by the Howard Hughes Medical Institute, called for broad-based microbiology training of young scientists.

"We live in an era when people are asking, 'Where are these diseases coming from?'" Martin Weiss notes. "We have to start with children to build up a base of knowledge about microbiology and infectious diseases. To do that, teachers must have a command of the subject."

Roughly one-fourth of all public school teachers in the New York City area cover science curriculum "out of license"—without training or certification. Budget cuts recently prompted veteran teachers to retire early, leaving less-experienced educators to introduce a microbiology curriculum targeting 7th graders.

And while teachers lack scientific knowledge, John Hammer says, they're also in desperate need of basic laboratory equipment. In a district characterized by traditionally underserved minorities and a high poverty rate, he adds, students deserve better educational opportunities.

The MICROLAB Institute gives teachers an intensive crash course in microbiology that goes beyond infectious diseases. "We found that teachers are extremely interested in the study of diseases caused by parasitic organisms, and we do talk about that," Hammer says. "On the other hand, we also try to let them know that microbiology is more than just the study of disease germs. Those are a subclassification of microorganisms, and probably only five percent of all species are actually associated with disease."

Training workshops include a field trip to a lake, where proper collection techniques are emphasized by Hall of Science staff and Pace University microbial ecologist Michael Levandowsky. Later, a method for maintaining collected specimens is introduced by Levandowsky and Douglas Zook, director of the Microcosmos Project at Boston University, a program that emphasizes a "low-tech" approach to science education.

Known as a Winogradsky column, the system consists of a large clear cylinder filled with mud. It is covered and placed in a sunny spot. Soon anaerobic microorganisms, which grow without oxygen, convene near the bottom of the column, Levandowsky explains. Oxygen-friendly, aerobic microorganisms thrive near the top of the column, where some oxygen remains. Since anaerobic microorganisms initiate a primitive, oxygen-free photosynthesis process, a rainbow of colors appears inside the cylinder.

Other MICROLAB activities include culturing, identifying, and observing single-celled organisms called protists. Since protists can thrive in baby food jars containing easily made, common growth media such as hay infusion, Hammer says, they can be cultured in classrooms where high-tech equipment is in short supply. Petri dishes are a more appropriate environment for culturing fungi and bacteria using different nutrient agars.

A yeast metabolism experiment, meanwhile, keeps teachers on their toes. As yeast inside a soda bottle consumes sugar and other foods, it produces carbon dioxide, filling a balloon that tends to fly away if improperly secured.

Although 84 teachers completed a MICROLAB workshop during the 1993–1994 school year, recruiting participants has been an uphill battle.

"To get five consecutive days, we have to schedule workshops for President's week, Easter week, Christmas week, and so on," Martin Weiss notes. "Even though we offer teachers a $300 stipend for the week, they don't like giving up that free time."

Weiss hopes more summer workshops will boost attendance. Ideally, he says, the New York City Board of Education should give teachers credit for attending workshops at any time.

Working with the Right Stuff

In New York City, teachers may spend only $100 per year on equipment. Unfortunately, good-quality microscopes cost more than that, and new equipment sometimes isn't delivered before the end of the school year. Consequently, a dozen teachers in the same school may wind up sharing a few dilapidated microscopes.

To correct such problems, the Hall of Science developed seven kits, which may be borrowed by teachers who attend a MICROLAB workshop.

Each portable kit contains 15 small FieldScope microscopes designed for field research and one larger Olympus microscope equipped with a video camera, suitable for classroom

demonstrations of microbial activity. A video projector, science games such as MicroBingo, posters, an instructional video, and miscellaneous supplies (from glass slides to batteries) are also included in each kit.

Because Hall of Science staff members restock and maintain the kits after use, Hammer says, teachers don't need to worry about replacing microscope bulbs or buying more yeast. Teachers do have to arrange for transportation to collect the kits, however. After a hectic rush-hour drive, teacher Susan Herzog needed her husband's help to load the heavy equipment into her car. Borrowing equipment would be even more difficult for teachers who don't own cars, she notes.

Established in 1962 as a science exposition center for the New York World's Fair, the Hall of Science operates several other successful teacher-training and equipment-rental programs, including STAR-LAB, an inflatable planetarium for astronomy studies. Another program, Design-It, includes a portable architecture system.

Such programs can be immensely helpful for teachers struggling to make sense of a complicated scientific curriculum. Though she has difficulty expressing herself in English, teacher Ana Boccanfuso serves bilingual students who desperately need greater access to science. "Some [workshop activities] were difficult for me," says Boccanfuso of Intermediate School 195 in New York City. "But trying to read and look up scientific words in a dictionary was helpful. I would like to have more classes in different areas of science, because it helps me, and that helps my students."

Institutional Profile

Annual attendance	230,000
Annual budget	$4,500,000
Annual education budget	880,000
Endowment	$35,000

PRATT MUSEUM

High Schoolers Unravel Mysteries of the Deep in Whale Project

Program Director
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The Pratt Museum is a natural history–natural science museum in Homer, Alaska. In 1993 the Howard Hughes Medical Institute awarded it $250,000 to initiate a uniquely Alaskan marine science program at Homer High School. The program uses the skeletal remains of a locally salvaged whale and human and marine resources unique to the area to develop a multidisciplinary approach to science education. The planning phase involves development of an instructional program with emphasis on ocean conservation. In a second phase, students, scientists, and museum staff study the whale and assemble the skeleton, suspending it in the school commons for exhibition. Through an outreach program, other schools and the general public will be introduced to the whale. Participants in the project include 65 high school students, 10–15 resource people, and two instructors. Study of the natural history of whales will range from local marine biology to broader issues of ocean conservation. Through analysis, research, bone preservation, skeletal articulation, and engineering, participating students will be directly involved in museum work.

In 1988 a 41-foot sperm whale became beached and died on the Alaskan Coast. Now, the whale's skeleton has become the focal point for a five-year science project targeting high school students and the general public in Homer, Alaska.

"We want to use this whale as a symbol of ocean life," explains museum director Betsy Pitzman, who organized the whale project after receiving the HHMI grant. "To us, the sperm whale represents the wealth and mystery and beauty of the ocean."

Since sperm whales are the deepest-diving mammals known, Pitzman adds, their behavior is poorly understood. As Homer High School students unravel the mysteries of the whale by studying its natural history, she says, they'll also learn about local marine biology and ocean conservation.

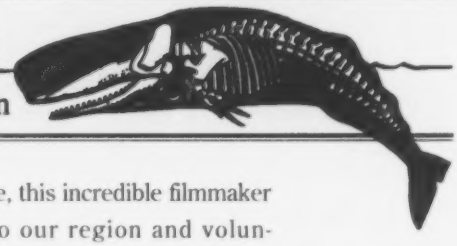
Cross-Disciplinary Teaching

In keeping with its "do-no-harm" policy, the Pratt Museum acquired its whale skeleton six years ago by salvaging a beached specimen. But the whale bones couldn't be displayed for several years. "We didn't have an indoor space large enough for the 10-foot-long skull," Pitzman explains.

Fortunately, the High School Commons—a dramatic three-story public space with a balcony—turned out to be just the place to display the specimen.

The Sperm Whale Project

a museum-high school collaboration



But how could the museum safely hang a huge whale skeleton over the heads of high school students and the general public in the middle of an earthquake zone? Before assembling the skeleton, Pitzman first assembled an advisory committee consisting of school administrators, teachers, parents, and students. The committee then hired a project facilitator with a strong background in marine science. A consulting engineer was also added to the instructional team. During the 1994–1995 school year, facilitator Rebecca May reports, an estimated 90 students will photograph, measure, research, articulate, and finally suspend the whale skeleton inside the school.

Study of the whale won't be limited to science courses, she says. Students will draw and photograph whale bones to enhance artistic expression. They'll also document the history of the project in English classes and debate about whaling practices during history lessons.

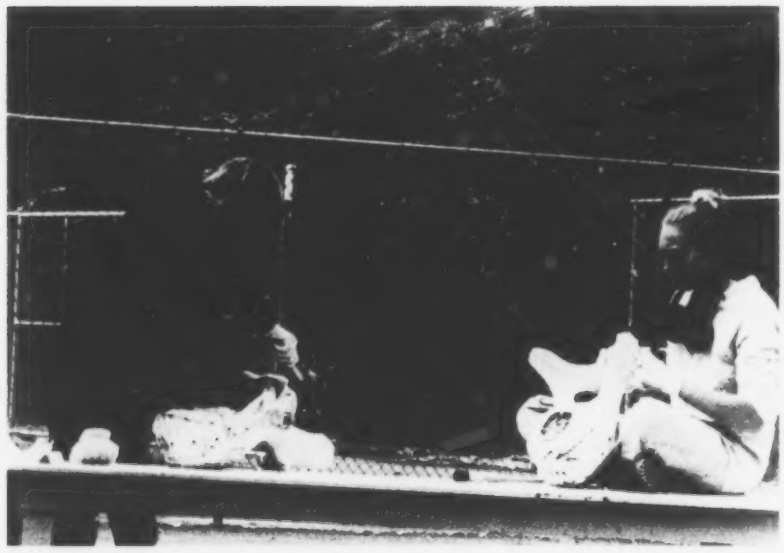
Some youngsters will even have a chance to work with award-winning filmmaker Daniel Zatz, who will be instructing them in the creation of a documentary about the whale project, thanks to a grant from a private foundation.

"We realized as we were getting under way that we didn't have a good way to document what we were doing," Pitzman notes. "Then by chance, this incredible filmmaker moved to our region and volunteered to help. Even if we don't find the funding to produce a final polished film, we'll have the raw materials to share our work with other museums and schools in the future."

As part of a Natural Resources Technology course, students will analyze the task of hanging a whale skeleton—a tough assignment requiring mathematics, biology, and engineering. Also during the course Pratt Museum zoologist and collections curator Betsy Webb will offer instruction in hands-on museum science involving marine collections.

Such cross-disciplinary research should help students understand the whale's role in the global environment, notes Homer High School principal Richard Krieger. "The curriculum will focus on the structure of the whale bone, how it supports the skeletal system, how it works in tandem with the whale's anatomy and the relationship of the whale to other mammals," Krieger says.

"Because everything is interrelated, it's natural to go from studying this large mammal to talking about what it feeds on, the ocean conditions required for its survival, and the geography of the regions where it lives."



Students measure and clean whale vertebrae in Homer, Alaska.

A Rich Heritage

The whale project is providing the citizens of Homer and surrounding regions with a unique opportunity to learn more about Alaskan culture and customs. Three percent of all Homer High School students are Alaskan Natives, Pitzman notes. Whaling is a longstanding tradition in Alaska, still practiced by the native populations under a government treaty that prohibits commercial harvesting. Pitzman hopes to present students with information about subsistence whaling practices.

"The issue of ocean conservation is complex, and some cultures are still dependent on whaling," she notes. "We feel that the Alaskan Native perspective is an important one for students to hear."

While Rebecca May is coordinating projects and activities with teachers, Pitzman is mapping out a plan to integrate the whale project into the Pratt Museum's exhibits and programs. From August through November 1994, for instance, science activities planned as part of the whale project made use of the Smithsonian Institution's traveling exhibition on the cultures of Alaska and Siberia. A highlight of the exhibitions was a performance and workshops at the high school, complete with native Siberian dancers and storytellers.

Already the whale project has generated intense excitement in the communities surrounding Homer High School. In response to the demand for more public information about the whale, Pratt Museum staffers this year are offering informal tours and lectures. Meanwhile, May's friends and acquaintances are constantly asking, "Is it together yet?"

The skeleton should be fully reassembled and suspended for display by the summer of 1995, she says. At that point, work will begin

on an interpretive exhibition. Ultimately, Pitzman says, the exhibition should serve all 450 students at Homer High School, plus other area students and the general public.

Because Homer High School is only a short distance from the Pratt Museum, Krieger expects that the whale exhibit will be incorporated into museum field trips planned by teachers from all over Alaska.

Senior high school student Jessica Klinker, who serves on Pitzman's advisory committee, says the citizens of Homer seem to take pride in their whale skeleton. And she adds—with no pun intended—that students are just now beginning to realize the enormity of the whale project. "It's a lot bigger than we thought," she says.

Institutional Profile

Annual attendance	35,718
Annual budget	$612,964
Annual education budget	$25,617
Endowment	$10,195

SOUTH DAKOTA DISCOVERY CENTER AND AQUARIUM

Little Island on the Prairie

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The South Dakota Discovery Center and Aquarium is a science-technology center in Pierre, South Dakota. In 1993 the Howard Hughes Medical Institute awarded it $175,000 to develop an outdoor ecostudy area on Discovery Island, a five-acre succession island on the Missouri River, formed as a result of sedimentation from the Oahe Dam and the channeling of the river. The center will prepare a K–12 science education program that uses the ecostudy area to study (1) water quality and its effect on flora and fauna, (2) the biological communities of the wetlands, (3) ecology of the Missouri River Basin, and (4) advanced topics in high school biology. A K–12 integrative science program uses hands-on science methods and experiments in which students make predictions, collect data, and interpret findings. Initially, three rural and two reservation pilot schools will test the program. Eventually it will be available to all rural and reservation schools (122,609 students, including 6,882 Native Americans).

A Community Commitment

Now in its fourth year, the Discovery Center and Aquarium, located on the prairies of South Dakota, was founded by community leaders who wanted visitors to experience the excitement and adventure of science. They envisioned it as a place where families could learn together and teachers could bring students to supplement and enrich their science offerings at school. That dream is now a reality.

"We have real credibility with the community, and the Discovery Center is valued by local people," says Terry Lewis, the education director.

Some 67,000 visitors, over half of them children, have been to the center. School districts from every county in the state have used the center's resources. The center offers programs such as the "guided discovery" workshops for students.

"In the aquarium we have the tanks stocked with fish that are native to South Dakota. In some of our workshops, we have the kids touch the fish, and we have many who have never touched a fish before," says Lewis.

There is also an Out Reach Van Program, which introduces the center's science activities to different communities whenever it goes on the road. Programs are enhanced by the expertise available from both state and federal agency staff living in the community. Many of these agencies are involved in the Discovery Island program.

In 1992 the Discovery Center and Aquarium designed the concept of an outdoor ecostudy area on Discov-

Discovery Island, a five-acre succession island on the Missouri River, is an outdoor ecostudy area of the South Dakota Discovery Center and Aquarium.

ery Island that formed the basis for its proposal to the Institute. Nearby La Framboise Island, which is maintained by the U.S. Army Corps of Engineers, will also be used in the project.

With these outdoor areas as the research setting, combined with interactive hands-on teaching, the center will prepare a K–12 science education program to study the effect of water quality on flora and fauna; the biological communities of the wetlands; ecology of the Missouri River Basin; and advanced topics in high school biology. This will give students in these rural and reservation settings a new awareness of the local ecology.

Without committed community involvement, the Discovery Center would not exist. That same commitment is evident in the Discovery Island project.

News of the HHMI grant traveled fast, and the town of Pierre, South Dakota, where the Discovery Center is located, is very excited about the new program. "There are not a lot of educational resources available to teachers and families in an area like this," says Lewis. "In South Dakota, a 90-mile drive to go to a science center is nothing. People realize the importance of this type of project."

South Dakota is noted for high standardized test scores and the strong work ethic of its people. Despite their motivation, the isolation of communities and the lack of resources have blocked the way for the schools to capitalize on their students' attributes. The project is particularly important because it will provide long-needed resources for the community, especially in small, rural schools.

Without proper equipment, it is impossible for teachers to offer any innovative hands-on teaching to the students. Also, teachers are often faced with teaching the entire curriculum, making it difficult to master one science field.

Because of the long distances between population centers and any science facilities, there is little networking among teachers. The Discovery Center provides a support system for teachers, and staff have

A student takes a break from one of the many activities offered at a water festival held by the Center in 1994.

found them eager to learn new ideas. These small, isolated communities need enriching opportunities in the sciences, like those offered by the center.

South Dakota has a large Native American population. The counties where the reservations are located have high poverty levels and provide little opportunity for science education. Native American students need opportunities to show that they can succeed in science.

What Will the Project Do?

Discovery Island is located on the banks of the Missouri River in Pierre, South Dakota. Located just offshore from the center, Discovery Island and La Framboise Island will be the site of trails that will provide students with an opportunity to explore their ecological riches. Eventually, guided walks will be available to the public.

The State Game and Fish Department donated a boat to the program, and dock facilities are planned. "Because we needed insurance to operate the boat, we spent six months investigating who would cover us. We kept coming up empty handed, and then one of the people on our advisory board made a couple of phone calls and was successful," says Lewis. "We really have some committed folks on board."

Program activities will be organized with age-appropriate materials. Staff will review existing materials and fill in the gaps with newly developed ones if needed. Participating schools will pilot and evaluate program materials. Materials that reflect Native American culture will be used to relate the science of the Native Americans to the science taught in the program.

Four program areas will be developed. In the Water Quality and Ecology module, students will learn by testing the water and analyzing the data gathered. From those data, predictions will be made about how altering the water chemistry will affect the biological community.

Students will study the biological communities by identifying the flora and fauna of the wetlands, prairie, forest, and marsh and river communities on the Discovery Island complex. Data collected from different sites of the Missouri River Basin will allow students to determine the effect that modern technology has had on the water quality.

Students in advanced biology classes will learn to use equipment such as spectrometers, and will be networked via computers with other students throughout the Missouri River Basin.

Teachers will be supported throughout the program and will receive help in adapting and organizing activities for their classroom. Once teachers become familiar with equipment at the center, it will be available on loan for use in their classrooms. Networking with other teachers will also help to foster the proliferation of hands-on science learning.

Just the Beginning

Staff have been busy this year getting the facilities ready for use and developing the curriculum. An advisory committee of individuals from state and federal agencies and community members have met to develop plans for the facilities.

The summer months were spent building trails and signs on Discovery and La Framboise Islands. With the help of a teacher advisory committee, the curriculum materials for the Water Ecology Unit are being piloted in the fall of 1994.

The center tested curriculum ideas at a water festival in the spring of 1994. This one-day event for 4th-grade students and their teachers elicited overwhelming support. "Both kids and teachers wanted more projects like it," says Lewis. The festival had 16 different activities and was staffed by wildlife and water quality professionals.

Members of youth and community groups were on hand to chaperone the 4th graders while the teachers visited a resource room with water-related activities and curriculum, which provided staff with needed insight about how to involve volunteer groups in Discovery Island activities.

"We are ready to go this fall with the program. Our teachers are excited and ready to start. Even though this is extra work for them, they're there because they want to be, and because they are committed," says Lewis.

Institutional Profile

Annual attendance	24,000
Annual budget	$188,500
Annual education budget	$27,600
Endowment	$61,400

STATEN ISLAND CHILDREN'S MUSEUM

Science on Stage

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The Staten Island Children's Museum is a children's and youth museum in Staten Island, New York. In 1993 the Howard Hughes Medical Institute awarded it $125,000 to provide Staten Island elementary school teachers with training and tools to teach science in an imaginative and engaging fashion. Three interrelated components are offered to four participating schools: (1) permanent science resource centers (stationary or mobile) stocked with equipment and materials for hands-on science experiments, combined with graphics, games, art projects, songs, scripts, and costumes for use during and after school; (2) teacher training in the use of visual and dramatic arts for teaching science to elementary school children; and (3) an eight-week museum residency at each school. The curriculum will be developed for 3rd- to 5th-graders in collaboration with school and district leaders. The science content of the program will be derived from two museum exhibits, Bugs and Other Insects and Wonder Water, and will comply with state and local curriculum requirements.

Science in Everyday Life

There has been a great deal of progress in the past year at the Staten Island Children's Museum to initiate the Howard Hughes Medical Institute grant. The museum's program takes a broad approach in enlisting teachers, children, and their families to make science both interesting and fun through experiential learning.

"Our program is designed to help students realize that science is really a part of our everyday life," says Elizabeth Egbert, assistant director of the museum. "It starts with helping the teachers feel comfortable with the science they're teaching," she adds.

Building on Previous Programs

Since 1976 the museum has been offering science to school-age children in the community and has supported the schools that educate them. The museum is fully booked annually with school classes from the entire New York City metropolitan area. In addition, science coordinators and elementary education teachers come from the local school system regularly for in-service training programs.

A unique facet of the museum's teacher education program is a concern for interrelating the arts, sciences, and humanities. Visual and theater arts professionals on the staff help to plan such programs as Sci-

Players in the Staten Island Children's Museum production of "Bugs and Other Insects," part of the Science on Stage program.

ence on Stage, which combines song, dance, humor, and audience participation with science learning. The Institute-funded endeavor is a natural extension of the museum's existing educational activities for both children and teachers.

Collaboration with the Local School District

Training a core group of local educators is one of the primary goals of the program. Program planners expect that these teachers can then go on to train others. Collaborating with the local school district will allow the museum to reach the greatest number of teachers. Needless to say, the local school district is very happy about the collaboration.

The New York State Regents have mandated that teachers use hands-on teaching methods for science. However, many elementary science teachers have not had the training or do not have the resources to comply with these mandates. When approached about the program, one educator said, "We are told what to teach, but not how to teach. Most of our teachers at the elementary level are overwhelmed by the content of the required syllabus and simultaneously fearful of giving children the wrong information."

The lack of materials to conduct exploratory learning is a critical issue for the school system. Constrained budgets result in a curriculum as well as an environment that is not conducive to hands-on learning. "This project is exciting," says Luann Martin, the science cluster teacher at P.S. 45. "To be able to go to teachers who do not have any materials and to ask them to think of all the

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supplies they've ever wanted is incredible."

How It Will Work

There are three components of the Staten Island Children's Museum program. A teacher training component, preceding the museum in-school residency, will be provided for teachers from a targeted school each year and will highlight the use of the visual and performing arts (music, dance, and drama) in science education. By combining the arts with science, the content is made more vivid and concrete for the child. Both the arts and science employ inquiry-based methods of learning that are key to acquiring scientific knowledge. This type of educational environment has flexibility and will reach more children, especially girls and minorities, say museum staff. The first museum teacher training was scheduled for the fall of 1994. Between 20 and 40 teachers are expected to be trained over the period of the grant.

With input from the school's staff, four participating schools will create permanent science resource centers (either stationary or mobile) that will contain the equipment and materials needed to do hands-on science experiments. Museum-designed activities (e.g., graphics, games, art projects, scripts, and costumes) will also be part of the resource centers. These materials will be integrated into the arts-based techniques that teachers are introduced to by museum staff.

Finally, in-school museum residencies will be centered around the creation of the resource centers and the development and implementation of a curriculum. The museum residency actually brings the program into the classroom. Science resource centers will be the focus and will determine how the residency is developed and implemented. Resource centers will be adjusted to meet the needs of the particular school. Teachers will use them as part of the curriculum developed in the training component.

Museum staff will assist in the creation of class projects and will help to plan for a Family Science Festival at the end of the residency. Involvement of families in this culminating event will complete the circle of learning and education, from the teacher to the child and family. Families will participate in hands-on activities, and parents will see firsthand how much their children have learned. Over the course of the grant, museum staff expect between 12 and 20 3rd- through 5th-grade classes to participate in the program.

Getting Under Way

The planning process for the creation of the first of four science centers is under way at the Staten Island Children's Museum. "We are in great shape to begin," says Egbert. "We're spending a lot of time in intense and very creative brainstorming sessions with the school district leadership and the participating teachers."

In the spring of 1994, planning meetings with project participants and museum staff began in earnest. Discussion focused on what educational goals the group wished to achieve, the atmosphere that exists in public schools concerning science education, the actions needed to reach the goals, and the methodology that would be used to reach them.

Meeting participants brainstormed and reached consensus about where the program was headed. The group agreed that the educational goal was to "address the need to link science to everyday life and create components of the program that would reach both the children and their family experientially." To address the existent school atmosphere, the group saw a need to create activities that empower children to follow their talents beyond the scope of the project while improving their critical thinking skills. Creating science centers that the entire school can use will allow teachers to implement these goals. Each participating school's individual curriculum needs will drive the creation of their resource center.

The first science center was created at P.S. 45, an economically diverse and well-integrated elementary school, in the fall of 1994. The first in-school residency will take place the following spring. Martin, the science cluster teacher at P.S. 45, will be working with the five 4th-grade classes at her school. The first curriculum area, Life Cycles, was revised and rewritten on the basis of group discussion. The curriculum outline is based on the concept of a journey of four different indigenous seeds and how they grow. This approach will help illustrate the plant life cycle by showing how seeds become roots and shoots, grow leaves and fruit, and then return to seed.

"This first classroom experience should give us concrete examples of where we will hit bumps, and allow us to fix them," says Egbert.

Discussions about evaluation of the program are ongoing, with Inverness Associates playing a major role in helping the museum create a formal strategy.

Martin is enthusiastic: "Science is a very forgotten subject, and to be able to get the creative people from the museum to put their energy into a curriculum is just fantastic. The program is a wonderful shot in the arm for science educators in this area."

Institutional Profile

Annual attendance	100,000
Annual budget	$1,081,900
Annual education budget	$411,500
Endowment	$333,000

THOMAS H. KEAN NEW JERSEY STATE AQUARIUM AT CAMDEN

New Aquarium Program Provides Safe Haven for Disadvantaged Students in Camden

Program Director

Julie Johnson

Assistant Director of Education

Thomas H. Kean New Jersey State Aquarium at Camden

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The Thomas H. Kean New Jersey State Aquarium at Camden, New Jersey, received $300,000 from the Howard Hughes Medical Institute in 1993 to support the Camden Aquarium Urban Science Enrichment Program. This five-year elementary and secondary school science education project has three interrelated components: a summer science camp, an after-school ecology club, and a high school junior staff program. The project provides science enrichment activities for underserved and disadvantaged urban children in Camden. It focuses on the biology and aquatic ecology of New Jersey and nearby areas. Through hands-on activities, field trips, role playing, role modeling, and high-impact demonstrations, students investigate the habitats and adaptations of plants and animals common to southern New Jersey; properties of fresh, salt, and estuarine systems; the physical and chemical composition of soil and its importance as a filtration system; and pollution, conservation, and emerging technologies.

In southern New Jersey, dozens of children exit yellow school buses and begin marching single-file along a grassy forest path. Scrambling down a muddy bank, they wade into a shallow creek, laughing. "Ms. Cintron, Ms. Cintron!" one child yells, lifting a small object for educator Nereida Cintron to see. "I found a fossil!"

Before long, other students have found sharks' teeth, fossilized portions of belemnites (squidlike creatures), oysters, and scallops deposited millions of years ago, when the creek bed lay beneath an ocean.

The fossil expedition was part of an ambitious new effort by the Thomas H. Kean New Jersey State Aquarium to serve elementary and high school students. Dubbed C.A.U.S.E.—for Camden Aquarium Urban Science Enrichment—the program provides job training for adolescent junior staff members, plus a summer science camp and an after-school ecology club for elementary students.

Supported by the HHMI grant, the program focuses on the biology and ecology of New Jersey. Students are learning, for example, about the habitats and adaptive behaviors of regional plants and animals. They are also studying the physical and chemical composition of regional soil, pollution, and water systems.

Perhaps more important, the science enrichment program offers a safe haven for young people in Camden's toughest neighborhoods, where vacant lots are littered with broken glass and derelict row houses are quickly commandeered by drug dealers and addicts. Described

in 1986 as the nation's poorest city, Camden is fighting its way back from a startling economic decline triggered by mass urban exodus 20 years ago.

As an anchor development, the two-year-old New Jersey State Aquarium is leading the charge for economic and cultural growth in Camden. Outreach programs for young people are a key component of the revitalization plan.

"We feel we have a responsibility to provide community improvement and educational programs," says Angela Wenger, an education specialist at the aquarium. "We want to make a difference in children's lives."

Summer Fun with Fossils

Children who took part in the 1994 C.A.U.S.E. summer camp enjoyed constructive play time in a creekbed, but they also learned about ocean formation, food webs, and energy flow, and about animal adaptations and marine archaeology.

While splashing in the creek, seven-year-old Tremaine Medley was delighted to share her knowledge of fossils. "The sharks lived here a long time ago," she explained. "When they died, their teeth fell out."

Oceans were the focus of this year's camp, which followed a 1993 pilot session emphasizing the Delaware River and surrounding urban environment. Subsequent camps will complement aquarium exhibits featuring coral reef systems and the New Jersey Pinelands, a million-acre wetlands region.

Christopher Francis (left) and Rashaad Williams display belemnites collected on a fossil expedition during the 1994 C.A.U.S.E. summer camp.

By 1998, Angela Wenger says, the aquarium expects to serve between 200 and 400 elementary students through its summer camp program. To ensure a 1-to-5 leader-student ratio, teen-aged junior staff members and young-adult counselors are hired to work with small groups of children. Educators like assistant principal Nereida Cintron and science teacher Bara Franklin of the Cooper's Poynt Family School also lend a hand.

A native of North Camden, camp counselor Vincent Rivera says inner-city youngsters desperately need access to educational activities.

"A lot of times, the kids don't have anything to do and they end up hanging out on the street," Rivera says. "If their family isn't there for them, their friends on the street

A wet hunt for fossils is both educational and refreshing.

become their family, and they get into some stuff that means trouble."

Cintron agrees. "Not only is the neighborhood tough, but there's nothing to do," she says. "We have a Basic Skills Improvement Program that the children can attend in the summer, but that only lasts four weeks."

Targeting Teens

Aquarium visitors ask Antonio Rodriguez the darnedest questions. As a junior staff member, 18-year-old Rodriguez is ready with answers whenever he's stationed near aquarium exhibits.

"There's one I get all the time," Rodriguez says through a grin. "We have these horseshoe crabs, right? They have these long, pointy tails. People always ask me, 'Is it poisonous?'—and they can see me touching it, right? Why would I be touching it if it was poisonous?"

Rodriguez was one of eight junior staff members trained during the 1993–1994 school year. Unfortunately, two students were unable to complete the program.

One young man was shot and paralyzed just a few days before Christmas while walking home from his second job. (Wenger says the student, though still paralyzed, is determined to finish school.) A second student became pregnant while a junior staff member. Yet another teenager almost quit the program when she became the target of a bitter custody battle between her mother and grandmother.

Despite a rocky first year, the C.A.U.S.E. program is expected to provide jobs for about 80 junior staff members and camp counselors over the next four years.

Training for junior staff members, recruited from Camden's Woodrow Wilson High School, includes information on oceanography, invertebrate and vertebrate biology, ecology, and interacting with the public. After training, the teens shadow senior staff members for six weeks,

then begin working directly with the public as exhibit educators.

Last year, junior staffers also took a cruise on a research vessel operated by the Institute of Marine and Coastal Sciences at Rutgers University. "They were pretty excited," Wenger says of the experience. "I doubt that many of them had ever been on a boat before."

The aquarium provides junior staffers and counselors with a much-needed stipend, as well as practical career experience and scientific knowledge. Participants reap other benefits, too.

Counselor Lisa Reyes, a college student majoring in child psychology, says her sense of humor improved when she began working with Cooper's Poynt students. "The kids are pretty good, but you have to remember they're children," she says. "In the summer, they want to have fun, and there's no reason why they shouldn't have fun while they're learning."

The aquarium's first six junior staff members are now fully trained and comfortable with their job responsibilities. But training the students required 39 hours of instruction. Wenger had originally planned just 16 hours, and the extra training put a major dent in the program budget. Family conflicts also interfered with the students' progress. Wenger and the aquarium's education director Julie Johnson hope to prevent similar problems next year by inviting parents to discuss the program before teens enroll.

Ecology and Outreach

Beginning in October 1994, summer camp participants have been encouraged to join an after-school Ecology Club, scheduled to meet monthly during the school year. Initially, Wenger says, students may study global and local environmental events by examining newspapers and magazines.

Specific activities might include development of an "urban safari trail" that leads children on a nature walk through the city. The Ecology Club will culminate in April 1995 with an Earth Day project designed by the students.

To track the program's success, Wenger says, junior staff members keep journals explaining what they've learned. Anecdotal reports from teachers, as well as science test scores, may help aquarium staff evaluate the progress of younger children, she adds.

Teacher Bara Franklin, meanwhile, is already using summer camp lessons in her science classes. "The summer camp helps me get to know the younger children better," she says. "It also helps them learn science. We might be doing an activity in class, and they can say, 'I remember this. I had a good time doing it!'"

Institutional Profile

Annual attendance	650,000
Annual budget	$11,012,756
Annual education budget	$990,840*
Endowment	$2,500,000

**Includes exhibits.*

WOODLAND PARK ZOOLOGICAL GARDENS

A Zoo Extends Itself to Better Reflect Its Community

Program Director
Teresa A. O'Connor
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Woodland Park Zoological Gardens
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Woodland Park Zoological Gardens is a zoo in Seattle, Washington. In 1993 the Howard Hughes Medical Institute awarded it $150,000 to conduct community outreach programs in environmental and wildlife conservation. Volunteers from a local African American church are trained as docents so that visitors to the zoo will find a staff more nearly reflective of the local population. By establishing more contacts with minority groups, the staff hopes to reach the entire community and encourage wider use of the zoo as an educational resource. During the grant period, it plans to offer hands-on classroom presentations and field trips for some 500 5th and 6th graders, many of them minority students. The children will examine animal specimens, build models, participate in live animal demonstration programs, and conduct field observations.

"I really wanted to do more with the math-science interface for my 5th graders at the Afrikan American Academy," says teacher Willa Williams-Gary, "but I was unsure how to go about doing it. When the Woodland Park Zoo people asked if I would be interested in working with them, I saw a terrific opportunity and took it."

Reaching Out to Community Partners

Williams-Gary and her students are now part of a major initiative of the Woodland Park Zoo to expand its educational offerings to new audiences, and especially to people of color in metropolitan Seattle. The zoo's HHMI-funded project intends to reach school children, their teachers, and their parents. Ultimately, the zoo hopes that teachers and parents will join with the zoo's docents to become program facilitators and guides, thus making visits more comfortable and worthwhile for new participants of all ages and backgrounds.

The zoo began by conferring with a member of their board of trustees, Rev. Samuel McKinney, of the predominantly African American Mt. Zion Baptist Church. Through him they met Rev. LaVerne Hall, director of Mt. Zion's Ethnic School, who was of great assistance in the early stages of the program. The zoo also used an existing Partners in Public Education partnership with Hawthorne Elementary School, which is part of a four-school network called the Powerful Schools Coalition. This strong early interface with the community assured the zoo of both good advice and ready introductions to schools, teachers, and parents.

Keeper Celwyn Scott with a barn owl at a Math and Science Outreach family event at the Woodland Park Zoo.

Early Parent and Teacher Involvement

Under the direction of project director Terry O'Connor, curator of education, staff members launched the first phase of the program. Debbera Stecher, senior bird keeper, Rosalyn Bass-Fournier, zoo docent, Celwyn Scott, keeper/educator, Dr. Yvette Archie, veterinarian, Diana Hernandez, education assistant, and Donna Thompson, former zoo project manager, organized a six-part training course for 17 teachers and parents. Since the zoo wanted to have teachers and parents working alongside zoo staff when programs were presented to classroom students, it was important for the adults to be familiar with the materials to be presented at the schools. These training classes were held on Thursday evenings at John Muir Elementary School and on Saturday mornings at Mt. Zion Baptist Church. O'Connor noted, "We worked with our participants in familiar surroundings and brought the zoo and its opportunities to them. This worked much better than when we tried to recruit docents through advertisements and announcements in community newspapers."

While the training session is content-rich, all the presentations involved hands-on activities and many opportunities for the participants to contribute to the program. The primary presenters were African American women. Their participation was of great importance, as they opened the eyes of the predominantly African American audience to the possibility of their children entering the zoo professions.

The training is introduced with a session on the community role of the Woodland Park Zoo, the zoo's commitment to conservation, and the functions of docents and volunteers. Next a keeper/educator discusses African mammals and leads an exercise in calculating and preparing proper diets for omnivores, herbivores, and carnivores. The third ses-

Yvette Archie talks about veterinary medicine at the Woodland Park Zoo during a Math and Science Outreach event.

sion is devoted to eggs and other features of birds, with a message about the conservation of endangered birds in zoos. The fourth session deals with the design of naturalistic exhibits and involves the group in the planning for the African Savanna exhibit. Next is a session on veterinary medicine, including a hands-on study of household pets. The workshop is wrapped up with comments on the preparation, education, and training necessary for zoo careers.

Five parent volunteers, plus Williams-Gary, then assisted zoo staff in presenting programs to 5th graders at John Muir Elementary, Whitworth Elementary, Hawthorne Elementary, and the Afrikan American Academy. "My students loved the program," reported Williams-Gary. "A real bonus was the live animals they brought—the kids loved the reptiles. Other specimens, like lion skulls, and skins and bones, and slides about African environments were very helpful as we prepared for our visit to the zoo." The Afrikan American Academy definitely is looking forward to the second year of the program.

Complementary Activities Provide Additional Perspectives

Three other activities complement the primary one. First, Stecher presented sessions for 300 girls at the Expanding Your Horizons career workshop sponsored by the Association of University Women in Tacoma and Marysville, Washington. Williams-Gary noted how this helped students understand the variety of jobs and careers that are available and the educational preparation required for each one.

Second, O'Connor recognized the need for multicultural sensitivity training of zoo staff. She took advantage of a four-hour workshop, Creating Access to Environmental Education and Interpretive Programs for Multicultural Populations, led by Running Grass, executive director of

the Three Circles Center for Multicultural Education in San Francisco. All presenters and education staff attended the session. This program was well received and raised a number of issues to be dealt with as the program continues to develop.

Third, the zoo hired a pair of high school summer interns, working with MESA (Mathematics, Engineering and Science Achievement) through the City of Seattle. Two young women, Tokunbo Fatuga from Nigeria, and Linh Lam from Vietnam, spent nine weeks working in the educational, animal management, and horticulture areas of the zoo. The interns also helped with summer program elements—classes for students at the Mt. Zion Ethnic School and for the Young Environmental Savers pilot program, which offers action-oriented environmental projects for youth from low-income, minority, and bilingual communities.

From the zoo's point of view, good progress has been made. The parent-teacher sessions have been tested and found successful, parents are involved in the classroom visits, and several of the parents are considering becoming docents. Participants were most forthcoming with suggestions for improvements, many of which already have been implemented, and other changes will be made for the second year's presentations. This last is very important, as a direct expectation of the zoo is that the 98 percent Caucasian docent corps will slowly come to resemble the complexion of the entire city.

Institutional Profile

Annual attendance	973,688
Annual budget	$9,200,000
Annual education budget	$801,873
Endowment	none

Appendices

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APPENDIX A

Attendees, 1994 Program Directors Meeting

Aprison, Barry
Museum of Science and Industry
Chicago, Illinois

Banks, Sharon
Gardner Academy Elementary School
San Jose, California

Barnes, Lehman
Museum of Science and History of Jacksonville
Jacksonville, Florida

Bedworth, Jacalyn
Minnesota Children's Museum
St. Paul, Minnesota

Bopp, Lisa
Museum of Discovery and Science
Fort Lauderdale, Florida

Brown, Carlene
New York Hall of Science
Corona, New York

Buxton, Barry
Health Adventure
Asheville, North Carolina

Calderon, Ismael
American Museum of Natural History
New York, New York

Chittenden, David
Science Museum of Minnesota
St. Paul, Minnesota

Combs, Dave
California Museum of Science and Industry
Los Angeles, California

Darmstadter, Nancy
Academy of Natural Sciences of Philadelphia
Philadelphia, Pennsylvania

DeBuhr, Larry
Missouri Botanical Garden
St. Louis, Missouri

Diamond, Judy
University of Nebraska State Museum
Lincoln, Nebraska

Dow, Peter
Buffalo Museum of Science
Buffalo, New York

Drew, Peggy
Cumberland Science Museum
Nashville, Tennessee

Eberbach, Catherine
New York Botanical Garden
Bronx, New York

Egbert, Elizabeth
Staten Island Children's Museum
Staten Island, New York

Eller, Stan
Homer High School
Homer, Alaska

Epps, Francina
Jones Business College
Edward Waters College
Jacksonville, Florida

Erikkson, Susan
Virginia Tech Museum of Natural History
Blacksburg, Virginia

Essig, Stephen
Carter House Natural Science Museum
Redding, California

Estes, Rachel
Discovery 2000
Birmingham, Alabama

Franklin, Bara
Cooper's Poynt School
Camden, New Jersey

Frazier, Mary
Fernbank Science Center
Atlanta, Georgia

Garcia, Shannon
Arizona Museum of Science and Technology
Phoenix, Arizona

Gil, Marisol
North Museum of Natural History and Science
Lancaster, Pennsylvania

Godfrey, Joyce
Memphis Pink Palace Museum
Memphis, Tennessee

Goudy, David
Montshire Museum of Science
Norwich, Vermont

Gould, Joan
Scotia-Glenville Children's Museum
Scotia, New York

Guttenberg, Richard
Audubon Institute
New Orleans, Louisiana

Hamadeh, Ann
Boston Public Schools Science Center
Dorchester, Massachusetts

Harbor, Maxcine
Northern High School
Baltimore, Maryland

Hemphill, Lynell
Chicago Housing Authority
Chicago, Illinois

Hernandez, Diana
Woodland Park Zoological Gardens
Seattle, Washington

Hoesterey, Roger
Parks and Community Services Department
Bellevue, Washington

James, Sylvia
National Aquarium in Baltimore
Baltimore, Maryland

Jaskulski, Robert
Cleveland Children's Museum
Cleveland, Ohio

Kase, Sandra
C.E.S. 42–Community School District 9
Bronx, New York

Kindig, Laura
Museum Magnet School
St. Paul, Minnesota

Krapfel, Paul
Carter House Natural Science Museum
Redding, California

Lewis, Terry
South Dakota Discovery Center and Aquarium
Pierre, South Dakota

Loret, John
Science Museum of Long Island
Manhasset, New York

Manipella, Addy
Staten Island Children's Museum
Staten Island, New York

Mardiney, Robert
Irvine Natural Science Center
Stevenson, Maryland

McLaughlin, Molly
Franklin Institute Science Museum
Philadelphia, Pennsylvania

McWilliams, Susan
High Desert Museum
Bend, Oregon

Molyneaux, Barbara
Imaginarium
Anchorage, Alaska

Nordell, Steven
Westbury School District
Old Westbury, New York

Pitzman, Betsy
Pratt Museum
Homer, Alaska

Rehder, Mark
Santa Fe Children's Museum
Santa Fe, New Mexico

Rowe, Peter
Discovery Museum–Learning Center
Sacramento, California

Rubesin-Eigler, Roslyn
Children's Discovery Museum of San Jose
San Jose, California

Sail, Ann
Scotia-Glenville Children's Museum
Scotia, New York

Scanlan, Kerry
Zoological Society of Milwaukee
Milwaukee, Wisconsin

Schatz, Dennis
Pacific Science Center
Seattle, Washington

Searles, Georgiana
North Carolina Museum of Life and Science
Durham, North Carolina

Semper, Robert
Exploratorium
San Francisco, California

Serrell, Beverly
Serrell and Associates
Chicago, Illinois

Siska, Janice
Chicago Academy of Sciences
Chicago, Illinois

Smith-Keller, Keley
South Dakota Discovery Center and Aquarium
Pierre, South Dakota

Stampley, Ester
Benjamin Franklin Elementary Math and Science Magnet School
New Orleans, Louisiana

Stelmah, Lynn
Lawrence Hall of Science
Berkeley, California

Stolk, Ruth
National Zoological Park
Washington, D.C.

Stromfors, Charlotte
Arizona Museum of Science and Technology
Phoenix, Arizona

Thiry, Mary
Zoological Society of Milwaukee
Milwaukee, Wisconsin

Tirrell, Peter
Oklahoma Museum of Natural History
Norman, Oklahoma

Weiss, Martin
New York Hall of Science
Corona, New York

Wenger, Angela
Thomas H. Kean New Jersey State Aquarium at Camden
Camden, New Jersey

Willow, Diane
Children's Museum
Boston, Massachusetts

Yambor, Kirsten
Ann Arbor Hands-On Museum
Ann Arbor, Michigan

Ziegler, Barbara
LAB 3000
Colorado Energy and Resource Educators
Littleton, Colorado

Guests

Baugh, Don
Chesapeake Bay Foundation
Annapolis, Maryland

Brown, Judy
Edison Career Center
Wheaton, Maryland

Fordis, Michael
National Institutes of Health
Bethesda, Maryland

Koepp, Dale
Woodrow Wilson National Fellowship Foundation
Princeton, New Jersey

Laws, Jeff
Poolesville High School
Poolesville, Maryland

McDonald, William
Montgomery County Public Schools
Rockville, Maryland

Moyer, Wayne
Montgomery County Public Schools
Rockville, Maryland

Shmookler, Sandra
Montgomery County Public Schools
Rockville, Maryland

APPENDIX B

Precollege Science Education Initiative for Science Museums, 1992–1993 Awards

Academy of Natural Sciences of Philadelphia Philadelphia, Pennsylvania	$100,000
American Museum of Natural History New York, New York	200,000
Ann Arbor Hands-On Museum Ann Arbor, Michigan	150,000
Arizona Museum of Science and Technology Phoenix, Arizona	250,000
Audubon Institute New Orleans, Louisiana	150,000
Buffalo Museum of Science Buffalo, New York	475,000
California Museum of Science and Industry Los Angeles, California	175,000
Carter House Natural Science Museum Redding, California	250,000
Chicago Academy of Sciences Chicago, Illinois	350,000
Children's Discovery Museum of San Jose San Jose, California	175,000
Children's Museum Boston, Massachusetts	275,000
Cleveland Children's Museum Cleveland, Ohio	275,000
Cumberland Science Museum Nashville, Tennessee	225,000
Discovery 2000[1] Birmingham, Alabama	125,000
Discovery Museum–Learning Center[2] Sacramento, California	225,000
Exploratorium San Francisco, California	175,000
Fernbank Museums Atlanta, Georgia	250,000
Franklin Institute Science Museum Philadephia, Pennsylvania	200,000
Health Adventure Asheville, North Carolina	100,000
High Desert Museum Bend, Oregon	250,000
Imaginarium Anchorage, Alaska	225,000
Irvine Natural Science Center Stevenson, Maryland	125,000
LAB 3000 Littleton, Colorado	100,000
Lawrence Hall of Science Berkeley, California	175,000
Memphis Pink Palace Museum Memphis, Tennessee	200,000
Milwaukee County Zoological Gardens Milwaukee, Wisconsin	200,000
Minnesota Children's Museum[3] St. Paul, Minnesota	125,000
Missouri Botanical Garden St. Louis, Missouri	125,000
Montshire Museum of Science Norwich, Vermont	225,000
Museum of Discovery and Science[4] Ft. Lauderdale, Florida	200,000
Museum of Science and History Jacksonville, Florida	175,000
Museum of Science and Industry Chicago, Illinois	400,000
National Aquarium in Baltimore Baltimore, Maryland	125,000
National Zoological Park Washington, D.C.	125,000
New York Botanical Garden Bronx, New York	175,000
New York Hall of Science Corona, New York	400,000
North Carolina Museum of Life and Science Durham, North Carolina	175,000
North Museum of Natural History and Science[5] Lancaster, Pennsylvania	100,000
Oklahoma Museum of Natural History Norman, Oklahoma	225,000
Pacific Science Center Seattle, Washington	225,000
Pratt Museum Homer, Alaska	250,000
Santa Fe Children's Museum Santa Fe, New Mexico	200,000
Science Museum of Long Island Manhasset, New York	250,000
Science Museum of Minnesota St. Paul, Minnesota	200,000
Scotia-Glenville Children's Museum Scotia, New York	100,000
South Dakota Discovery Center and Aquarium Pierre, South Dakota	175,000
Staten Island Children's Museum Staten Island, New York	125,000
Thomas H. Kean New Jersey State Aquarium at Camden Camden, New Jersey	300,000
University of Nebraska State Museum Lincoln, Nebraska	500,000
Virginia Tech Museum of Natural History Blacksburg, Virginia	175,000
Woodland Park Zoological Gardens Seattle, Washington	150,000
Total	$10,625,000

[1] *Formerly Discovery Place of Birmingham.*
[2] *Formerly the Sacramento Science Center.*
[3] *Formerly Children's Museum.*
[4] *Formerly Discovery Center.*
[5] *Formerly North Museum of Franklin and Marshall College.*

APPENDIX C

Precollege Science Education Initiative for Biomedical Research Institutions, 1994 Awards

Boston University School of Medicine Boston, Massachusetts	$300,000
Bowman Gray School of Medicine of Wake Forest University Winston-Salem, North Carolina	400,000
Brigham and Women's Hospital Boston, Massachusetts	175,000
Carnegie Institution of Washington Washington, D.C.	200,000
Cold Spring Harbor Laboratory (DNA Learning Center) Cold Spring Harbor, New York	400,000
Columbia University College of Physicians and Surgeons New York, New York	250,000
East Carolina University School of Medicine Greenville, North Carolina	250,000
Foundation for Blood Research Scarborough, Maine	175,000
Fred Hutchinson Cancer Research Center Seattle, Washington	425,000
Georgetown University (Medical Center) Washington, D.C.	175,000
Harvard Medical School Boston, Massachusetts	175,000
Indiana University School of Medicine Indianapolis, Indiana	225,000
Johns Hopkins University School of Medicine Baltimore, Maryland	175,000
Massachusetts General Hospital Boston, Massachusetts	375,000
Medical College of Pennsylvania Philadelphia, Pennsylvania	250,000
Morehouse School of Medicine Atlanta, Georgia	325,000
Mount Sinai School of Medicine New York, New York	350,000
Oklahoma Medical Research Foundation Oklahoma City, Oklahoma	325,000
Pennsylvania State University Hershey Medical Center Hershey, Pennsylvania	250,000
Ponce School of Medicine Ponce, Puerto Rico	300,000
Rockefeller University New York, New York	175,000
Southern Illinois University School of Medicine Carbondale, Illinois	225,000
Temple University School of Medicine Philadelphia, Pennsylvania	175,000
University of Alabama at Birmingham Birmingham, Alabama	375,000
University of California–San Francisco San Francisco, California	200,000
University of Cincinnati College of Medicine Cincinnati, Ohio	175,000
University of Illinois at Chicago Chicago, Illinois	175,000
University of Kansas School of Medicine Wichita, Kansas	175,000
University of Massachusetts Medical Center Worcester, Massachusetts	175,000
University of Medicine and Dentistry of New Jersey New Jersey Medical School Newark, New Jersey	175,000
University of Medicine and Dentistry of New Jersey Robert Wood Johnson Medical School Piscataway, New Jersey	175,000
University of Mississippi Medical Center Jackson, Mississippi	175,000
University of Nevada School of Medicine Reno, Nevada	200,000
University of North Dakota School of Medicine Grand Forks, North Dakota	450,000
University of Rochester School of Medicine and Dentistry Rochester, New York	250,000
University of South Dakota School of Medicine Sioux Falls, South Dakota	175,000
University of Southern California School of Medicine Los Angeles, California	200,000
University of Texas Medical Branch at Galveston Galveston, Texas	175,000
University of Utah School of Medicine Salt Lake City, Utah	325,000
University of Washington (School of Medicine) Seattle, Washington	200,000
Washington University School of Medicine Saint Louis, Missouri	300,000
West Virginia University Robert C. Byrd Health Sciences Center Morgantown, West Virginia	175,000
Total	$10,325,000

APPENDIX D

Precollege Science Education Initiative for Science Museums, 1992–1993 Awards, by State

Alabama

Discovery 2000, Birmingham

Alaska

Imaginarium, Anchorage

Pratt Museum, Homer

Arizona

Arizona Museum of Science and Technology, Phoenix

California

California Museum of Science and Industry, Los Angeles

Carter House Natural Science Museum, Redding

Children's Discovery Museum of San Jose

Discovery Museum–Learning Center, Sacramento

Exploratorium, San Francisco

Lawrence Hall of Science, Berkeley

Colorado

LAB 3000, Littleton

District of Columbia

National Zoological Park, Washington, D.C.

Florida

Museum of Discovery and Science, Ft. Lauderdale

Museum of Science and History of Jacksonville

Georgia

Fernbank Museums, Atlanta

Illinois

Chicago Academy of Sciences, Chicago

Museum of Science and Industry, Chicago

Louisiana

Audubon Institute, New Orleans

Maryland

Irvine Natural Science Center, Stevenson

National Aquarium in Baltimore

Massachusetts

Children's Museum, Boston

Michigan

Ann Arbor Hands-On Museum, Ann Arbor

Minnesota

Minnesota Children's Museum, St. Paul

Science Museum of Minnesota, St. Paul

Missouri

Missouri Botanical Garden, St. Louis

Nebraska

University of Nebraska State Museum, Lincoln

New Jersey

Thomas H. Kean New Jersey State Aquarium at Camden

New Mexico

Santa Fe Children's Museum, Santa Fe

New York

American Museum of Natural History, New York City

Buffalo Museum of Science, Buffalo

New York Botanical Garden, Bronx

New York Hall of Science, Corona

Science Museum of Long Island, Manhasset

Scotia-Glenville Children's Museum, Scotia

Staten Island Children's Museum, Staten Island

North Carolina

Health Adventure, Asheville

North Carolina Museum of Life and Science, Durham

Ohio

Cleveland Children's Museum, Cleveland

Oklahoma

Oklahoma Museum of Natural History, Norman

Oregon

High Desert Museum, Bend

Pennsylvania

Academy of Natural Sciences of Philadelphia

Franklin Institute Science Museum, Philadelphia

North Museum of Natural History and Science, Lancaster

South Dakota

South Dakota Discovery Center and Aquarium, Pierre

Tennessee

Cumberland Science Museum, Nashville

Memphis Pink Palace Museum, Memphis

Vermont

Montshire Museum of Science, Norwich

Virginia

Virginia Tech Museum of Natural History, Blacksburg

Washington

Pacific Science Center, Seattle

Woodland Park Zoological Gardens, Seattle

Wisconsin

Milwaukee County Zoological Gardens, Milwaukee

APPENDIX E

Precollege Science Education Initiative for Biomedical Research Institutions, 1994 Awards, by State

Alabama

University of Alabama at Birmingham, Birmingham

California

University of California–San Francisco, San Francisco

University of Southern California School of Medicine, Los Angeles

District of Columbia

Carnegie Institution of Washington, Washington, D.C.

Georgetown University (Medical Center), Washington, D.C.

Georgia

Morehouse School of Medicine, Atlanta

Illinois

Southern Illinois University School of Medicine, Carbondale

University of Illinois at Chicago, Chicago

Indiana

Indiana University School of Medicine, Indianapolis

Kansas

University of Kansas School of Medicine, Wichita

Maine

Foundation for Blood Research, Scarborough

Maryland

Johns Hopkins University School of Medicine, Baltimore

Massachusetts

Boston University School of Medicine, Boston

Brigham and Women's Hospital, Boston

Harvard Medical School, Boston

Massachusetts General Hospital, Boston

University of Massachusetts Medical Center, Worcester

Mississippi

University of Mississippi Medical Center, Jackson

Missouri

Washington University School of Medicine, Saint Louis

Nevada

University of Nevada School of Medicine, Reno

New Jersey

University of Medicine and Dentistry of New Jersey New Jersey Medical School, Newark

University of Medicine and Dentistry of New Jersey Robert Wood Johnson Medical School, Piscataway

New York

Cold Spring Harbor Laboratory (DNA Learning Center), Cold Spring Harbor

Columbia University College of Physicians and Surgeons, New York City

Mount Sinai School of Medicine, New York City

Rockefeller University, New York City

University of Rochester School of Medicine and Dentistry, Rochester

North Carolina

Bowman Gray School of Medicine of Wake Forest University, Winston-Salem

East Carolina University School of Medicine, Greenville

North Dakota

University of North Dakota School of Medicine, Grand Forks

Ohio

University of Cincinnati College of Medicine, Cincinnati

Oklahoma

Oklahoma Medical Research Foundation, Oklahoma City

Pennsylvania

Medical College of Pennsylvania, Philadelphia

Pennsylvania State University Hershey Medical Center, Hershey

Temple University School of Medicine, Philadelphia

South Dakota

University of South Dakota School of Medicine, Sioux Falls

Texas

University of Texas Medical Branch at Galveston, Galveston

Utah

University of Utah School of Medicine, Salt Lake City

Washington

Fred Hutchinson Cancer Research Center, Seattle

University of Washington (School of Medicine), Seattle

West Virginia

West Virginia University Robert C. Byrd Health Sciences Center, Morgantown

Puerto Rico

Ponce School of Medicine, Ponce

APPENDIX F

Precollege Science Education Initiative for Science Museums, 1992–1993 Awards, by Type of Institution

Aquaria

Audubon Institute, New Orleans, Louisiana

National Aquarium in Baltimore, Maryland

Thomas H. Kean New Jersey State Aquarium at Camden, New Jersey

Botanical Gardens/Arboreta

Audubon Institute, New Orleans, Louisiana

Missouri Botanical Garden, St. Louis, Missouri

New York Botanical Garden, Bronx, New York

Children's and Youth Museums

Children's Discovery Museum of San Jose, San Jose, California

Children's Museum, Boston, Massachusetts

Cleveland Children's Museum, Cleveland, Ohio

Discovery 2000, Birmingham, Alabama

Minnesota Children's Museum, St. Paul, Minnesota

Santa Fe Children's Museum, Santa Fe, New Mexico

Science Museum of Long Island, Manhasset, New York

Scotia-Glenville Children's Museum, Scotia, New York

Staten Island Children's Museum, Staten Island, New York

General Science Museums

Discovery 2000, Birmingham, Alabama

Exploratorium, San Francisco, California

Franklin Institute Science Museum, Philadelphia, Pennsylvania

LAB 3000, Littleton, Colorado

Museum of Discovery and Science, Ft. Lauderdale, Florida

Museum of Science and History, Jacksonville, Florida

Science Museum of Long Island, Manhasset, New York

Science Museum of Minnesota, St. Paul, Minnesota

Natural History–Natural Science Museums

Academy of Natural Sciences of Philadelphia, Pennsylvania

American Museum of Natural History, New York, New York

Audubon Institute, New Orleans, Louisiana

Buffalo Museum of Science, Buffalo, New York

Carter House Natural Science Museum, Redding, California

Chicago Academy of Sciences, Chicago, Illinois

Exploratorium, San Francisco, California

Fernbank Museums, Atlanta, Georgia

High Desert Museum, Bend, Oregon

Irvine Natural Science Center, Stevenson, Maryland

Memphis Pink Palace Museum, Memphis, Tennessee

North Museum of Natural History and Science, Lancaster, Pennsylvania

Oklahoma Museum of Natural History, Norman, Oklahoma

Pratt Museum, Homer, Alaska

Science Museum of Long Island, Manhasset, New York

University of Nebraska State Museum, Lincoln, Nebraska

Virginia Tech Museum of Natural History, Blacksburg, Virginia

Science-Technology Centers

Ann Arbor Hands-On Museum, Ann Arbor, Michigan

Arizona Museum of Science and Technology, Phoenix, Arizona

California Museum of Science and Industry, Los Angeles, California

Cumberland Science Museum, Nashville, Tennessee

Discovery Museum–Learning Center, Sacramento, California

Health Adventure, Asheville, North Carolina

Imaginarium, Anchorage, Alaska

Lawrence Hall of Science, Berkeley, California

Montshire Museum of Science, Norwich, Vermont

Museum of Science and Industry, Chicago, Illinois

New York Hall of Science, Corona, New York

North Carolina Museum of Life and Science, Durham, North Carolina

Pacific Science Center, Seattle, Washington

South Dakota Discovery Center and Aquarium, Pierre, South Dakota

Zoos

Audubon Institute, New Orleans, Louisiana

Milwaukee County Zoological Gardens, Milwaukee, Wisconsin

National Zoological Park, Washington, D.C.

Woodland Park Zoological Gardens, Seattle, Washington

APPENDIX G

Precollege Science Education Initiative for Biomedical Research Institutions, 1994 Awards, by Type of Institution

Academic Health Centers

University of Alabama at Birmingham, Birmingham, Alabama

University of California–San Francisco, San Francisco, California

University of Illinois at Chicago, Chicago, Illinois

University of Mississippi Medical Center, Jackson, Mississippi

West Virginia University Robert C. Byrd Health Sciences Center, Morgantown, West Virginia

Independent Research Institutions

Carnegie Institution of Washington, Washington, D.C.

Cold Spring Harbor Laboratory (DNA Learning Center), Cold Spring Harbor, New York

Foundation for Blood Research, Scarborough, Maine

Fred Hutchinson Cancer Research Center, Seattle, Washington

Oklahoma Medical Research Foundation, Oklahoma City, Oklahoma

Rockefeller University, New York, New York

Medical Schools

Boston University School of Medicine, Boston, Massachusetts

Bowman Gray School of Medicine of Wake Forest University, Winston-Salem, North Carolina

Columbia University College of Physicians and Surgeons, New York, New York

East Carolina University School of Medicine, Greenville, North Carolina

Georgetown University (Medical Center), Washington, D.C.

Harvard Medical School, Boston, Massachusetts

Indiana University School of Medicine, Indianapolis, Indiana

Johns Hopkins University School of Medicine, Baltimore, Maryland

Medical College of Pennsylvania, Philadelphia, Pennsylvania

Morehouse School of Medicine, Atlanta, Georgia

Mount Sinai School of Medicine, New York, New York

Pennsylvania State University Hershey Medical Center, Hershey, Pennsylvania

Ponce School of Medicine, Ponce, Puerto Rico

Southern Illinois University School of Medicine, Carbondale, Illinois

Temple University School of Medicine, Philadelphia, Pennsylvania

University of Cincinnati College of Medicine, Cincinnati, Ohio

University of Kansas School of Medicine, Wichita, Kansas

University of Massachusetts Medical Center, Worcester, Massachusetts

University of Medicine and Dentistry of New Jersey New Jersey Medical School, Newark, New Jersey

University of Medicine and Dentistry of New Jersey Robert Wood Johnson Medical School, Piscataway, New Jersey

University of Nevada School of Medicine, Reno, Nevada

University of North Dakota School of Medicine, Grand Forks, North Dakota

University of Rochester School of Medicine and Dentistry, Rochester, New York

University of South Dakota School of Medicine, Sioux Falls, South Dakota

University of Southern California School of Medicine, Los Angeles, California

University of Texas Medical Branch at Galveston, Galveston, Texas

University of Utah School of Medicine, Salt Lake City, Utah

University of Washington (School of Medicine), Seattle, Washington

Washington University School of Medicine, Saint Louis, Missouri

Teaching and Research Hospitals

Brigham and Women's Hospital, Boston, Massachusetts

Massachusetts General Hospital, Boston, Massachusetts

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Meeting of Predoctoral and Physician Postdoctoral Fellows, Program and Abstracts (annual)

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Enriching the Undergraduate Laboratory Experience, 1993

Institutional Strategies for Enhancing Undergraduate Science Education, 1993

Science Education: Expanding the Role of Science Departments, 1995

Precollege Science Education Program

Science Museums: Creating Partnerships in Science Education, 1994

Science Museums: Enlisting Communities in Science Education Partnerships, 1995

Holiday Lectures on Science (brochure) (annual)

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Undergraduate Biological Sciences Education Program

Undergraduate Biological Sciences Education Program (annual)

Precollege and Public Science Education Program

Precollege Science Education Program (annual)

International Program

International Program (biennial)

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Graduate Science Education Program

Information for Medical Student Fellows and Fellowship Institutions (annual)

Information for Predoctoral Fellows and Fellowship Institutions (annual)

Information for Physician Postdoctoral Fellows and Fellowship Institutions (annual)

Undergraduate Biological Sciences Education Program

Information for Colleges and Universities Awarded Undergraduate Grants (annual)

Precollege and Public Science Education Program

Information for Science Museums and Biomedical Research Institutions Awarded Precollege Grants (annual)

International Program

Information for International Research Scholars and Grantee Institutions (biennial)

Research Resources for Medical Schools Program

Research Resources for Medical Schools Program

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Directory of Medical Student Fellows

Directory of Physician Postdoctoral Fellows

Undergraduate Biological Sciences Education Program

Undergraduate Program Directory

Precollege Science Education Program

Precollege Science Education Program Directory

International Program

International Research Scholars Program Directory: Australia, Canada, Mexico, New Zealand, United Kingdom (available fall 1995)

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